BELL TELEPHONE QUARTERLY

VOL. XVIII JANUARY, 1939 NO. 1

A WAR GAME TEST OF TELEPHONE SERVICE

THE LABORATORY—A POTENT SOURCE OF PROGRESS IN INDUSTRY

TRENDS IN THE TRAINING OF TELEPHONE OPERATORS

THE BELL SYSTEM PRESENTATION TO 1939 WORLD'S FAIR AUDIENCES

I. The Golden Gate International Exposition

II. The New York World's Fair of 1939

MEASUREMENTS AND TESTS IN TELEPHONE RESEARCH

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

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VOL. XVIII NO. 1

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE INFORMATION DEPARTMENT OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY, 195 BROADWAY, NEW YORK, N. Y.

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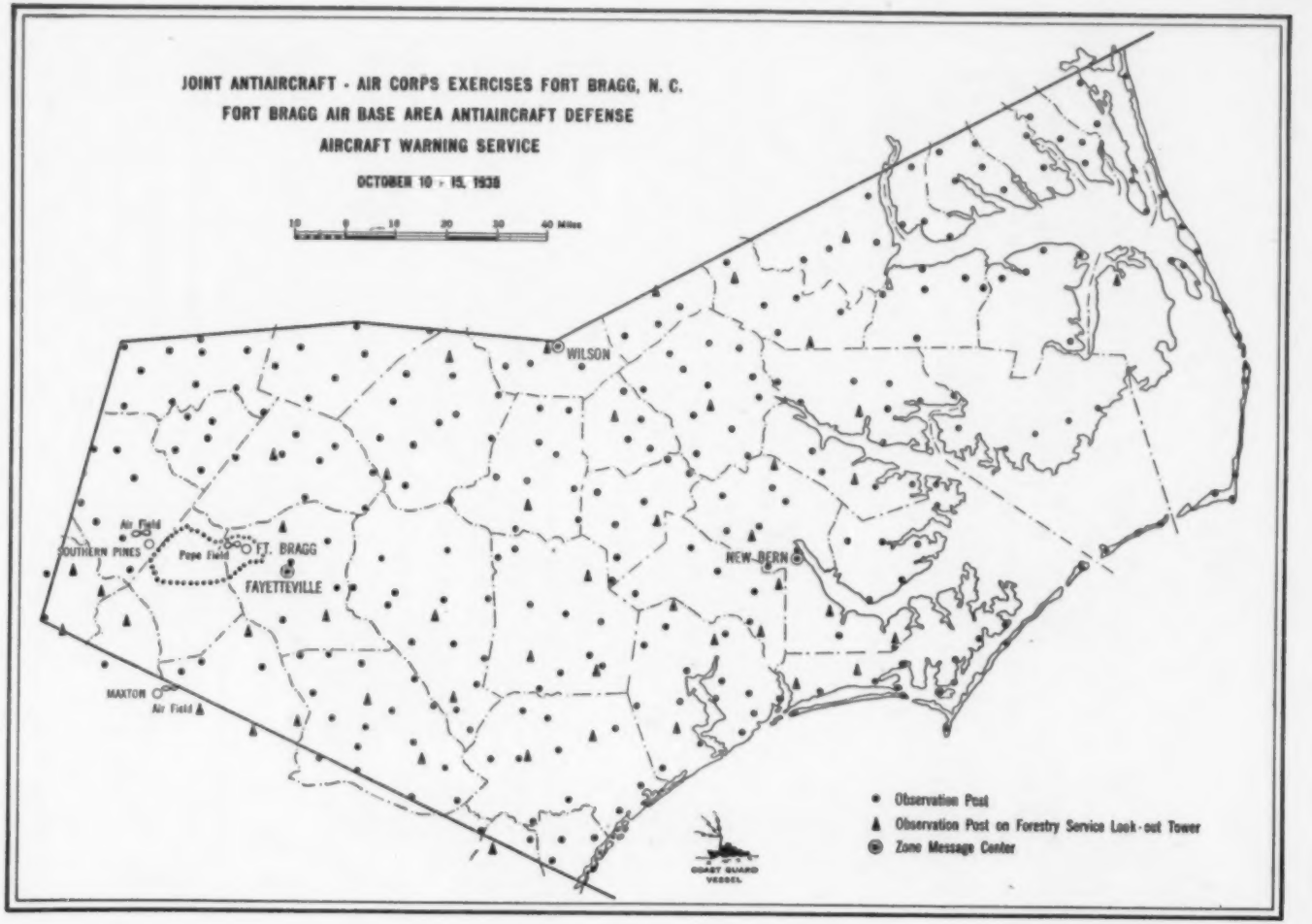
A War Game Test of Telephone Service

WAR IN NORTH CAROLINA. During the early moonlit hours of an October morning a squadron of "enemy" bombing planes roared inland across the coast in a surprise attempt to penetrate the defenses of Fort Bragg. The "Black" forces were attacking. It was the beginning of the joint exercises of the Air Corps and Anti-Aircraft Artillery of the United States Army in eastern North Carolina, October 10–15.

On the morning of October 10, Brigadier General Fulton Q. C. Gardner, commanding the "Blue" forces defending Fort Bragg near Fayetteville, N. C., was expecting a raid by enemy aircraft launched, theoretically, from carriers off the Carolina coast. His command included air squadrons located at Pope Field near Fort Bragg, Maxton Field at Maxton, N. C., and Knollwood Field at Southern Pines, together with anti-aircraft artillery, machine gun, searchlight and other special units of the Army. The 51st Signal Battalion from Fort Monmouth, New Jersey, commanded by Major Harry E. Storms, was charged with the operation of military communications under the technical direction of Colonel Thomas C. Spencer, Signal Officer for the Blue forces.

Dotted over 20,000 square miles of eastern North Carolina, in an area extending from the Virginia boundary on the north to a point near Wilmington on the south and inland for from 100 to 150 miles, civilian and other non-military observers were on the alert to detect the approach of hostile aircraft and warn the defending troops. These observers, a hastily organized staff of some 2,000 farmers, merchants, doctors, lawyers and housewives, were the eyes and ears of a far-flung aircraft warning net spread over 39 counties.


JOINT ANTIAIRCRAFT - AIR CORPS EXERCISES FORT BRAGG, N. C.
FORT BRAGG AIR BASE AREA ANTIAIRCRAFT DEFENSE
AIRCRAFT WARNING SERVICE
OCTOBER 10 - 15, 1938
10 0 10 20 30 40 Miles
WILSON
Air Field
SOUTHERN PINES
Pope Field
FT. BRAGG
FAYETTEVILLE
NEW BERN
MAXTON
Air Field
COAST GUARD VESSEL
Observation Post
Observation Post on Forestry Service Look-out Tower
Zone Message Center

A Test of Commercial Telephone Systems

The entire terrain covered by the exercises was divided into three Aircraft Warning Zones and further subdivided into eight-mile squares, 319 of them. At or near the center of each square an observation post ("OP") was located. Each OP, with the exception of seven provided with radio equipments of the Army Signal Corps, Coast Guard ships or amateurs, was connected by regular commercial telephone service with the nearest telephone exchange. In most OPs, as in the 46 posts located on the tops of lookout towers of the Forestry Services and those in Coast Guard stations along the coast, telephone connections already in use for normal peacetime service were utilized. These telephones were used by observers in reporting, through normal exchange and toll connections of the 20 commercial telephone companies operating in the area, to the appropriate Zone Message Centers, manned by the Army and established at New Bern, Wilson and Fayetteville, N. C., the principal operating centers of the long distance telephone wires in each of the three aircraft warning zones. Ship reports went to their base ports by radio and from there to the zone message center by land lines.

The three Zone Message Centers were each connected to a Sector Message Center at Fort Bragg by private telephone line and by a private line teletypewriter circuit. Reports received at zone centers were evaluated, coördinated, and forwarded immediately to headquarters at Fort Bragg by both telephone and teletypewriter for distribution to the Army officers directing the defense measures. Between General Gardner's headquarters at Fort Bragg and the headquarters of the Blue air forces, artillery and other defense troops, special telephone and teletypewriter services were established by the telephone companies as required by the Army.

At defense headquarters at Fort Bragg a large map of the area was mounted on one of the walls. The location of each

observation post was indicated by a red light, and as posts successively reported the presence of hostile aircraft, a string of glowing red lights showed the path of the invaders. Green lights traced the course of defense planes. Loud speakers enabled officers and others watching the progress of the attack to hear reports as they came in, giving a vivid picture of the progress of the enemy penetration. Radio Station WPTF of Raleigh had a temporary studio here for broadcasting instructions to the civilian population.

All reports from observation posts were handled as regular collect station-to-station telephone calls and, although given emergency treatment by telephone operators, did not take precedence over commercial connections already established, as would be required in time of war. Observers in placing calls for Zone Message Centers preceded their call by the word "Flash" which told the operator that this was an aircraft warning report to be handled in accordance with special "wartime" instructions.

The Black invading forces consisted of about 70 planes, including a number of the famous "flying fortresses," and were based at Langley Field, Virginia, under command of Brigadier General Arnold N. Krogstad. Theoretically these enemy planes were launched for their raids from "Black" aircraft carriers off the coast of North Carolina.

The First "Attack"

The early morning hours of October 10 were anxious ones not only for General Gardner and his staff, who were depending for their first word of an invasion on the alertness and discernment of a small, hastily chosen and trained band of civilians, each listening anxiously through the night for the first sound of droning motors, but also for the telephone men and women in exchanges all over the area, on whom depended the successful and rapid transmission of the news that war had spread its shadow over North Carolina.

At about 4:00 A.M. Captain Fred J. Gillikin, United States Coast Guard, was at his observation post at the tip of Cape Lookout. Suddenly he heard the roar of motors from the skies; but apparently going east! Invaders should be headed west, but nevertheless he must warn headquarters. He turned to his telephone, signaled the operator and the first "Flash" aircraft warning message was on the wires.

The operator connected him with the Zone Message Center at New Bern and Captain Gillikin reported the first hostile incident of the "war." What he actually said was "Lisbon 44. Many airplanes heard. 4:05 A.M. Medium altitude, course east. Lisbon 44." Far above the eastward flying planes, six giant "flying fortresses" shot directly toward Fort Bragg, counting on their tremendous speed to insure surprise; but no speed in the air equals the speed of the message on the wires, and it was only a matter of minutes after the red light indicating Captain Gillikin's report had flashed on the map at headquarters before a string of other lights, each representing a report from other alert observers, clearly traced the flight of the bombing forces, and long before the bombers could arrive at their objectives, defense squadrons had been alerted, cold motors warmed, and planes were roaring off to intercept the invaders, while artillery crews had ample time to prepare to receive the visitors.

The vigilance and effectiveness of the observers had several unexpected tests. On the morning of October 15 a large enemy bomber, equipped with a "silencer" to reduce the sound of the motor, flew into the area at over 12,000 feet. It was reported five times by the civilian aircraft warning network and picked up readily near Fort Bragg by anti-aircraft observation posts manned by artillery men. The same day a strange plane was reported, the reports tumbling in over each other from alert observers. Passengers on an Eastern Airlines "Main Liner" got an unanticipated thrill when a whole

squadron of "Blue" pursuit planes dropped in on their flight. Commercial planes had agreed not to enter the area during the exercises and this one lost no time in leaving.

Other exercises followed, two each day during the six-day period of the maneuvers. Various devices were tried by the invading air forces, such as laying smoke screens over defending gun positions previously located by reconnaissance planes, or by attacking during bright moonlight when search lights had difficulty in picking up invading bombers. Sometimes there were discussions among military observers and experts as to whether an attack had reached its objective and been successful or not. There was never any question, however, as to the efficiency of the civilian observers in detecting hostile flights, and as to the dependability of the network of commercial communications which carried the warnings to defense headquarters. Flying 4,000 feet the first night to train observers, invading bombers later flew at 18,000 feet, 20,000 feet and 24,000 feet, but they could not escape the eyes and ears of the civilian observers, who never failed to see or hear them and to get the word through to Fort Bragg within three minutes.

A "Blackout" Warning

On the evening of October 13 the telephone network received its first test in handling "Blackout" orders. When six giant bombers headed in past Cape Hatteras, the civilian-observer telephone network gave the defense immediate warning that an attack was on the way. At 7:01 P.M. General Gardner's order "Blackout immediately" was telephoned to Zone Message Centers by the Sector Message Center at Fort Bragg.

Over the commercial telephone systems to telephone chief operators, to "Blackout Chiefs" in the different communities, to Broadcasting Stations WPTF and WFTC, the order was passed along by prearranged methods. Blackout Chiefs used

ELECTRICALLY OPERATED WARNING NET MAP BOARD AT DEFENSE HEADQUARTERS, FORT BRAGG

U. S. ARMY SIGNAL CORPS PHOTOS

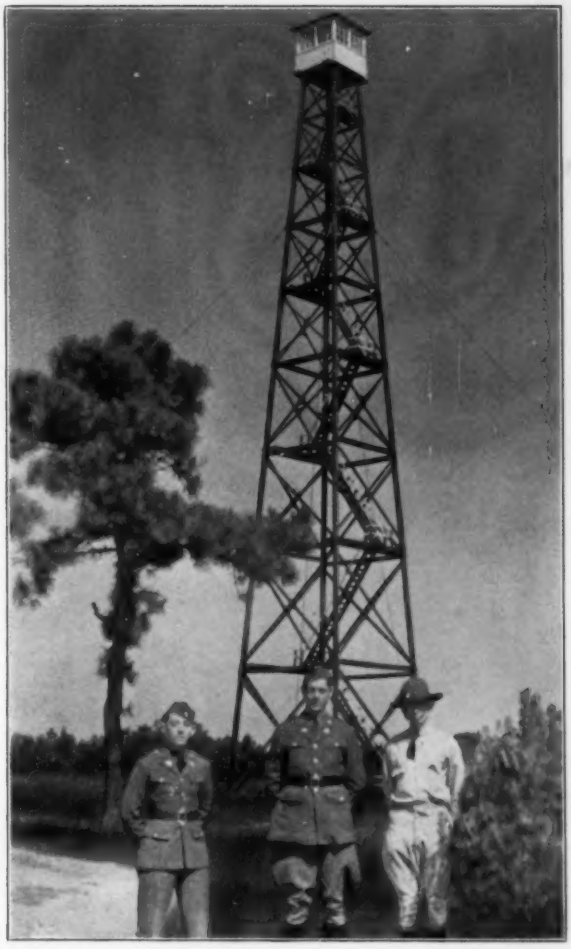
TELEPHONE OPERATORS, WARNING NET MAP BOARD AT FORT BRAGG

ZONE MESSAGE CENTER AT FAYETTEVILLE, N. C.

U. S. ARMY SIGNAL CORPS PHOTOS

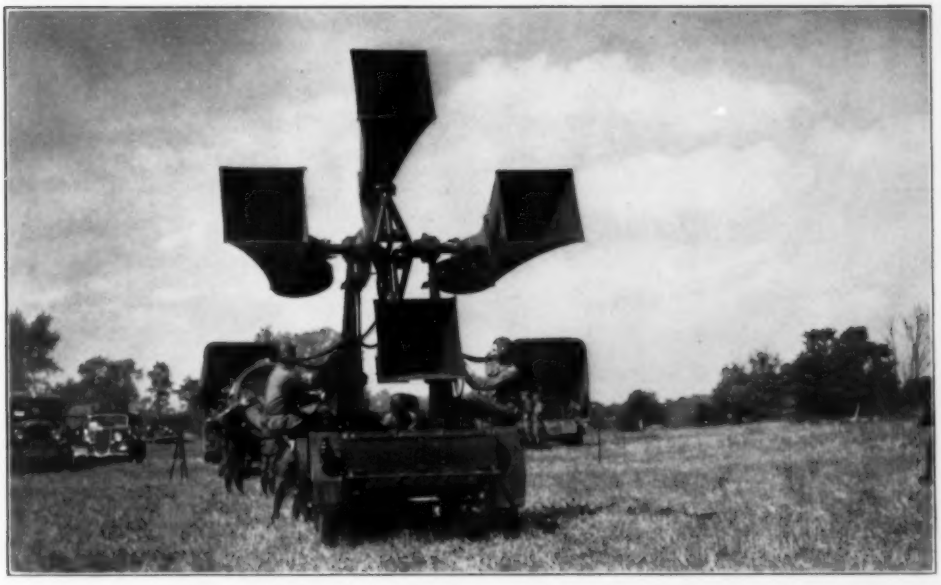
TELETYPEWRITER OPERATORS, SECTOR MESSAGE CENTER, AT FORT BRAGG

Observation Post on Forestry Service Lookout Tower

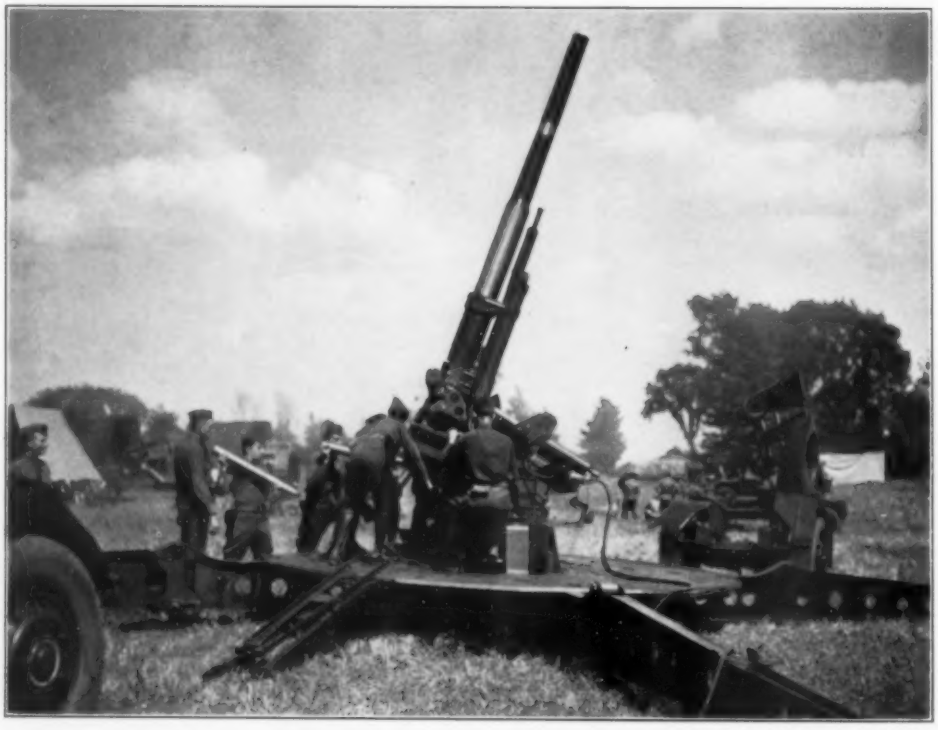


U. S. ARMY SIGNAL CORPS PHOTOS

Below: Sound Locator Used by the Anti-Aircraft Artillery



ANTI-AIRCRAFT MACHINE GUN IN ACTION



U. S. ARMY SIGNAL CORPS PHOTOS

THREE-INCH ANTI-AIRCRAFT GUN

sirens, bells, blinking street lights and other methods of signaling the townspeople that all lights must be extinguished. The warning at Deep Run was given by a citizen who blew on a fox horn which was reported not only to have been successful as a signal to the neighbors as far as three miles away but also to have drawn an enthusiastic response from the Carolina hound dogs in the vicinity. In some communities the power companies, after several warning "blinks," cut off the power. The "Blackout" lasted until 7:47 P.M., when the order "Lights on" was transmitted from Fort Bragg in the same way.

The speed with which the telephone network functioned in transmitting the "Blackout" order is shown by the fact that the average elapsed time on 76 long distance telephone calls to 49 towns and on 22 local calls in five towns was less than half a minute. In handling these 98 calls, an average of less than 30 seconds elapsed from the time the telephone operator in a given town received the "Blackout" order from the Zone Message Center until a connection had been established to the telephone of a "Blackout" chief and the call had been answered. The "Lights on" order was also handled with the same speed. While these calls undoubtedly would have taken longer to complete if the telephone personnel and the "Blackout" chiefs had not had advance warning, nevertheless the rapidity and accuracy with which they were handled was remarkable.

Although 66 towns were darkened, many motorists apparently did not receive or did not understand the radio warnings and their lights furnished easily discernible highway patterns to the invading planes. Thus, while opinion was divided as to the success of the "Blackout" as a military defensive measure, there was no division of opinion concerning the successful functioning of the commercial telephone systems in transmitting raid warnings to the civilian population.

The Wire Network

The telephone network utilized in the Carolina maneuvers, in addition to the lines and exchanges of the Southern Bell Telephone and Telegraph Company and of the Carolina Telephone and Telegraph Company, which serve a large part of the area in which the exercises were carried on, included exchanges of the following telephone companies:

Central Carolina Telephone Co., Southern Pines
Central Electric & Telephone Co., Charlottesville, Va.
Chesapeake & Potomac Tel. Co. of Va., Richmond, Va.
Colerain Telephone Co., Colerain
Eastern Telephone Company, Bethel
Ellerbe Telephone Company, Ellerbe
Faison Telephone Company, Faison
Garner Telephone Company, Garner
Hamilton Telephone Company, Hamilton
Heins Telephone Company, Sanford
Laurel Hill Telephone Company, Laurel Hill
Newport and Western Carteret Tel. Co., Newport
Norfolk and Carolina Telephone Co., Elizabeth City
Parkton Telephone Company, Parkton
Pender Telephone Company, Burgaw
Piedmont Telephone Company, Aberdeen
Pine Bluff Telephone Company, Pine Bluff
Princeton Telephone Company, Princeton.

The coördination of these commercial communication systems was directed for the telephone companies by Lieutenant Colonel S. G. F. Rathborne of the Southern Bell Company, a veteran of the Signal Corps in the Spanish-American and World Wars, and by Mr. W. C. Darrow, Commercial Manager of the Carolina Telephone and Telegraph Company. Prior to the exercises, operators in telephone exchanges to which observers' telephones were connected were instructed in special practices for handling aircraft warning reports. Civilian observers were trained in their duties by Army instructors from

the 51st Signal Battalion, assisted by local posts of the American Legion.

A preliminary test was given the entire system of telephone and teletypewriter lines on Sunday, October 2, when over 200 "Flash" messages were sent during an imaginary air raid. During this test the average interval between the time each civilian observer placed his call and its final reception at the Sector Message Center at Fort Bragg was 3 minutes, 13 seconds.

Warning Reports Speedily Transmitted

To the telephone companies which coöperated in these maneuvers, the tests showed that their normal facilities, even in the sparsely settled coastal regions of North Carolina, were adequate to provide communications for an aircraft warning service. Only one minor change was made in toll circuit arrangements prior to the test, involving the removal of a toll station from a through toll circuit between Fayetteville and Clinton; otherwise, ordinary existing circuit facilities were used. No toll or local lines had to be built and only five or six temporary telephones had to be installed at observation posts for observers.

The speed with which warning reports were transmitted by telephone, including the preliminary test, the week's exercises, and the "Blackout," averaged 36 seconds. This was the elapsed time from the time the civilian observer's signal was received at the local telephone switchboard until the bell rang in the Zone Message Center. The Army personnel at the Zone Message Centers answered immediately. The report of the Signal Officer in charge of communications for the exercises stated that on the average only 2 minutes, 37 seconds elapsed from the time an observer heard or saw an invading flight until his report was received at defense headquarters at Fort Bragg. During this interval of just over two and one-half minutes, the observer had to get to his telephone and

place his call; the telephone operator completed the call to the Zone Message Center; the observer made his report and this report was relayed by Army personnel to Fort Bragg over the private wires. Some 2,600 aircraft warning calls, of which only 1.4 per cent were even slightly delayed by "no circuit" conditions, were handled by the telephone systems during the week.

Aside from the strictly military questions upon which the maneuvers threw much valuable light, the effectiveness of a civilian-manned aircraft warning net using commercial telephone service was clearly demonstrated by the exercises. General Krogstad, commanding the invading air forces, summed this up by saying, "As a result of the exercises concluded tonight it appears certain that a warning net manned by public-spirited citizens constitutes an important service to defending anti-aircraft and pursuit."

CARROLL O. BICKELHAUPT

Acknowledgment is made to Mr. C. S. Bolen of the *Southern Telephone News* of the Southern Bell Telephone and Telegraph Company for assistance in preparing this article, and to the Chief Signal Officer of the United States Army for the photographs used as illustrations.

The Laboratory—A Potent Source of Progress in Industry

An Address Delivered at the 32nd Annual Convention of The Association of Life Insurance Presidents, in New York City, December 2, 1938, by Dr. Frank B. Jewett, Vice President, American Telephone and Telegraph Company, and President, Bell Telephone Laboratories, Inc.

THE industrial research laboratory as we have it today is relatively a very new addition to the machinery of applied science industry. Although superficially it may appear to be the modern edition of the experimental departments or laboratories of the 1880's and 1890's, it is basically quite different and infinitely more potent in influencing the progress of industry.

The first embryonic industrial research laboratories appeared shortly after 1900 in the fields of applied electricity and chemistry—both products of fundamental science research and both relatively new areas of industrial exploitation. This was absolutely true as to applied electricity, in which the major part of all commercial development had taken place subsequent to 1875. Applied chemistry, although a much more ancient art, had been vastly stimulated by the fundamental science discoveries of the latter decades of the nineteenth century.

In both these fields it was apparent by 1900 that fundamental science knowledge had outstripped industry's ability to utilize it by application of the methods then in use. It was clear also that the gap was widening. A few men sensed that if the situation was to be rectified and industry insured of full and prompt application of new knowledge, three things were necessary: (1) trained research men; (2) the introduction into industry of the philosophy and techniques of the scientific method, which had proven its power in fundamental sci-

ence; and (3) organization of the new group and its methods as a team and as an integral part of industry.

At first progress was slow. There were few trained men who were interested in and available for industry; proper experimental tools suitable for industrial problems were few and in many cases non-existent; management was skeptical of the value of the new "expense" department, as it was frequently termed, and the older "practical" men were in many cases frankly antagonistic. In addition, there were no guides as to how best to coördinate the new activity with the existing organization.

Industrial Laboratories are Accepted

Gradually, however, and with ever increasing acceleration, progress was made. Problems which were clearly beyond the capacity of the existing organizatioin were solved and confidence and respect developed; tools were created; universities began to attract and train men for a life in industrial rather than fundamental science; the team was organized and began to pour out on industry applications of new knowledge, the utility (in many cases even the existence) of which was unsuspected by management; and the value of organized industrial research as an instrument of progress was certified to by the spread of the idea into more and more fields.

The period of the World War and the two decades since have witnessed an astounding growth in the number, size, and functionalizatiion of industrial research laboratories. There is now little or no question raised as to their value. Through it all, the fields of their origin are still largely the fields in which they have attained their largest size, their most complete functionalization, and their greatest efficiency. As one surveys the fields of industry based on applied science, he cannot but be struck by the fact that those which have made the most progress and are in the strongest position are those in which the research laboratory is well developed and its func-

tion and value well understood and supported. Nor can he fail to be struck by the fact that many industries, once healthy and powerful but now in a distressed condition, are those in which the research laboratory is either poorly developed or non-existent and the management lacking in a real understanding of its functions and possibilities.

Volumes have been written about the achievements of the industrial laboratory. Most of it is true in the main, although some of it has been dressed up in gaudy clothes by the publicity man, much to the annoyance of his research associate. Whatever the basis, there are probably few who do not admit that the laboratory does produce astounding results. Many go further and credit it with ability to do the impossible.

While all of this is now taken more or less for granted, there is one aspect of industrial research which it seems to me has thus far failed to receive the attention it deserves. I refer to appraisal of the research laboratory and to the attitude of the management toward this function of their business by those called upon to examine and advise concerning the stability of an undertaking prior to the investment of funds. Were I called upon to form such a judgment of an applied science undertaking, these points would be the first I would inquire about. If I found the attitude of management indifferent or essentially uninformed and the research function poorly organized, I would consider the business unstable no matter what the current financial statement might show.

To me such a condition would evidence danger both from competitors in the same field of activity and more danger from entirely unsuspected competition of new alternative goods or services from outside. If, on the contrary, the research function was well organized and supported and the attitude of management was based on really informed understanding, I would consider that the business was insuring against future contingencies and was in a strong position to maintain leadership and to survive.

Possibly a life spent mainly on the research and development side of a highly technical applied science industry has caused me to accord an undue weight to these factors among the many that must be considered by those contemplating the safe investment of funds. Whether this is so or not, clear understanding of what organized industrial research is capable of doing for the business of which it is a part cannot but convince one that it is a very potent factor in determining the success of the undertaking.

Functions of the Industrial Laboratory

Primarily and principally, the research laboratory produces new and improved things in a specialized field. It takes the established facts of fundamental science research and, using exactly the same powerful tools by which these facts were obtained, it manipulates them to produce old things better and more cheaply or entirely new things of interest to the industry. These alone would justify the maintenance of the laboratory, since they are the things which guarantee leadership.

But the research laboratory does much more than this. In so far as its achievements are subject matter for patent protection, it provides management with a currency which is more potent than gold in insuring complete freedom of action and in some cases even the right to live. Modern applied science industry is so complex, involves so many things of science, and is developing rapidly in so many directions, that no single unit, however large and however well equipped its research department, can hope to produce *all* the new ideas which are essential to its well-being. When one of these necessary ideas is developed and patented on the outside, a license to use must be purchased. If the idea is in the hands of a competitor, money alone may be of no avail with an unwilling seller. Where, however, the prospective purchaser is possessed of an adequate research department, it can more frequently than not provide a currency in kind which can be used in a bartering

operation of cross-licenses. In many cases this barter currency or wampum is already at hand, produced in the primary operation of the laboratory, and so the new thing is purchased without addition to the capital or operating accounts.

With the growth in number, size, and efficiency of industrial research laboratories, their potentialities for producing new things embarrassing to competitors has become increasingly evident. The result is a growing tendency in cross-licensing to provide automatically and in advance for an interchange of rights throughout the duration of the contract.

A principal reason for this necessity is because the power of organized research is primarily the power of trained minds employing a powerful method and manipulating a vast store of established facts. Thus the organization can turn its weapons of creation in any one of many directions and, almost over night, become as skillful as a similar group long established in the field.

Charting the Future

In another direction also the research laboratory is a powerful aid to management, particularly when a large part of its activities are directed toward a somewhat distant future. Such activities mark out accurately the future path of industrial progress and so enable management to make plans with a much higher degree of certainty than would be possible otherwise. Likewise, they place it in position to judge quickly and accurately the value of a new idea or trend injected from the outside and for which substantial values are claimed by its proponents.

The larger the proportion of the laboratory's work that is devoted to the problems which deal with the fundamental rather than the current interests of the industry, the more valuable in general are the results. This is true both as to the new things it produces and in its aid to management in meeting competition and in planning for the future.

The great modern applied science industry is a complex affair in which the coöperative functioning of many departments frequently masks the fundamental factors on which the success or failure of the business ultimately depends. In the last analysis, these are physical things, and it is safe to say that no amount of ability in the financial or commercial departments can more than temporarily offset inherent deficiencies in the physical things in which the business is grounded. When these are allowed to become obsolete, the operating departments and the business begin to decline. It is the function of the research laboratory to prevent this obsolescence.

The power of the industrial research laboratory resides in the philosophy of controlled experimentation and in organized coördinated attack by trained specialists on each element of a problem. It differs from the fundamental science research laboratory only in that the work of the latter is but loosely coördinated and that it has a definite utilitarian objective for its work rather than a mere seeking after new knowledge for its own sake. In it, every problem to be attacked is first analyzed and dissected into its component parts, each one of which becomes the problem of a specialist or group of specialists. When their work is completed, the parts are synthesized into a complete solution.

The process is one which, when properly carried out, practically precludes the possibility of a major technical failure in the act of commercialization. The reason for this is that the final solution is one arrived at by the discovery and correction of a large number of minor defects or errors of assumption. As a result, the chance of a major defect remaining in the final answer is practically non-existent.

Many of the great applied science industries which are of major importance to us at present had their origins in the laboratory and owe their present state and their future prospects to industrial research. To name but a few, this is true of applied electricity, whether in the fields of light and power or

of communication; of organic and inorganic chemistry; of sound and light as they appear in talking motion pictures; in many forms of metallurgy; of everything pertaining to aeronautics; to the internal combustion engine; and to a host of other things. In every field, each step forward is making us more dependent on the laboratory and is taking the laboratory deeper into the realm of fundamental science.

The Telephone Exemplifies Research

While innumerable illustrative examples to show all this can be selected from any field of applied science, it may be interesting in conclusion to cite a few from the field of electrical communication, which is the one I am most intimately familiar with. Mainly they are the work of Bell Telephone Laboratories, the research department of the Bell System.

Possibly the most striking thing about telephone service in the United States and the one most commented on and inquired about is the completing of an asked-for connection to a distant telephone anywhere on the continent in a few seconds and while the calling subscriber remains at the telephone. It is a thing which could not have been done a few years ago and which practically cannot be done now anywhere else in the world.

That it is possible is because the research men have solved the problems of creating adequate transmission circuits from every central office to every other central office at such low cost that they can be provided in sufficient profusion to guarantee against "circuit busy" conditions in the vast majority of cases even at times of peak demand. They have done this by applying much new knowledge in many new ways. They have developed powerful energy-amplifying devices which have made it possible to give better transmission over fine copper wires than could be given a few years ago over wire many times larger and so many times more costly. Even this,

however, was not sufficient to permit vaulting the economic hurdle on many of the routes. Since mechanical stability and integrity place a limit to reduction in wire size long before the electrical limits reached, this hurdle could only be jumped by making each circuit carry many conversations at the same time.

Present success in this direction may be judged by the fact that for certain classes of long distance circuits, systems are now standard in which sixteen separate telephone conversations are now transmitted simultaneously over the same facilities which a few years ago were capable of handling but a single conversation. We also have in experimental operation systems which will transmit many hundred messages over a single channel.

While these statements are not to be construed as meaning that the added facilities are obtained without cost, they are obtained at a fraction of the cost that would be entailed in providing them otherwise—a cost so high as to be economically prohibitive.

Still having in mind the problem of "no delay" service and its dependence on a profusion of circuits on every route of a vast network, let us turn now to an entirely different area in which the laboratory has had to operate in order to make the service possible.

Between the big cities, with their large volume of social and business intercourse involving telephony, the problem is relatively simple, once the transmission problem is solved. Here the amount of traffic is sufficient to justify groups of direct trunk circuits used exclusively for terminating business, and inter-city business over them is handled somewhat like business between two central offices in the same city. It would, however, be most unsatisfactory to the public to have one grade of expeditious service between big cities and an entirely different and inferior service everywhere else. Just what is involved in assuring to the subscriber in Eastport, Maine, urgently desiring to call San Juan Capistrano, California, or to

one in Red Wing, Minnesota, wishing to talk to Biloxi, substantially the same kind of service he would obtain on a call from New York to San Francisco?

Obviously, no matter how cheap the transmission channels might be—even if they cost nothing—it would be impossible to provide direct circuits between every pair of central offices. One call in a lifetime would be the measure of usage over most of the circuits, and yet the telephone company must be prepared to give that call instantaneously on demand if it is made.

What the telephone company can and does provide are sufficient circuits from all offices, however small, to their nearest toll centers and of proper transmission characteristics to handle all the local and long distance service that may be offered. What the research laboratory has to cope with, therefore, is the problem of creating mechanism for connecting circuits together instantaneously on demand and, in addition, to make it so cheap and reliable and so adequate from a supervisory standpoint that it too can be installed in profusion without killing cost or without unnecessary drag on the use of circuits. On many of the unusual connections that are asked for, a half dozen or more switches are required; and yet the connections are established while the calling party remains at the telephone and the resulting circuit between the distant telephones is a good speech channel.

This problem is so vast and intricate that it could not possibly be solved except through the mechanism of thoroughly organized industrial research. Its ramifications have led us into practically every nook and cranny of fundamental physical science and to the development of inanimate devices which have seemingly human intelligence.

The story of transoceanic radio telephony, by which the great wire networks of separated continents are connected together; of radio broadcasting; of communication to ships and aeroplanes; of modern message telegraphy and phototelegraphy and their operation simultaneously with telephony, and a host

of other adventures in electrical communication, all present much the same picture of a powerful method in operation.

Nor is the end of the road in sight, since each step forward makes possible many other steps in the same direction if we have but the desire, will, and intelligence to take them. In this field, what men of imagination fifty years ago envisioned largely as an act of faith, viz., a world-wide telephone system so complete, adequate, and cheap as to offer no substantial bar to full and free intercourse, now seems positively and certainly attainable.

As mentioned earlier, similar stories can be told of every field where organized industrial research has been introduced into applied science. In conclusion, all I would say is that the research laboratory, if not the most potent source of progress in industry, is certainly one of the most potent. If proof of this is still wanting, just picture to yourselves what would happen to applied science industries if the contributions of the laboratory during the past two decades were to be suddenly withdrawn. Many of them would vanish, and all would shrivel to crude affairs measured by present day standards. Untold thousands of those now gainfully employed would be added to those without work, and the public would be deprived of goods and services which we have come to consider necessities rather than novelties or luxuries.

FRANK B. JEWETT

Trends in the Training of Telephone Operators

THERE are approximately 115,000 telephone operators in the Bell System and, under ordinary conditions, the maintenance of this organization will require the employment and training of some 25,000 inexperienced girls each year. The general methods of training these operators have been described on various occasions, as, for example, in the January, 1931, issue of the BELL TELEPHONE QUARTERLY. But interesting and significant changes are taking place in this training, and it is these recent trends that the ensuing article attempts to depict.

It is a story of a more natural working relationship which underlies much of the recent progress in the direction of personalizing the service we render our customers.

THE PERIOD OF SCHOOLS

It will be an aid to the better understanding of present day trends in operator training to review briefly former practices, and a natural starting point is the familiar operator training department *—a detached school with its classrooms and practice switchboard where for many years most new employees received their initial training. In these "schools," as many as fifteen to twenty students were assigned to an instructor in a classroom, where they heard lectures, and took part in drills and studies—all with the object of learning the processes and conditions of their work. These classrooms were modeled and conducted along the conventional lines of elementary schoolrooms and about three-quarters of the student day was spent in them.

* This discussion is essentially of conditions in larger places. There were, of course, no training departments in smaller places.

At the practice switchboard, the students handled simulated calls under the direction of a different group of instructors from those presiding over the classrooms. About one-quarter of the student day was devoted to this activity. Because of the cost of the practice equipment and fluctuating demands, it was rarely practicable to provide enough equipment to give more of this kind of practice.

The training in the training department was, of necessity, abstract. Usually, students were being trained for several central offices having varying operating conditions, which resulted in a wider spread of training than required for any one office. At the end of the prescribed period in the training department, the new operator went to a central office where she was assigned to a coach during an appreciable interval before she was ready to take her place as a regular operator.

In recent years, the training of long distance students had been modified in certain respects. The practice switchboard had been replaced by a small demonstration unit, located in the classroom, and several days elapsed before the students practiced at regular switchboard positions. As in the local training departments, the instructors were separate groups of specialists, who, as a rule, were not under the supervision and direction of the chief operator. Here also, the training was centered in classrooms, although the students were in small groups. Prominent in this plan was a textbook from which the students studied the standard methods of handling calls.

While there have been exceptions, of course, these arrangements are representative of the general plan.

Training Today

A sustained and growing attempt has been made during the last few years to view the essential facts and conditions of training so as to see them in true perspective. In application, this broad approach means building a structure of basic under-

lying principles to support all our training. At first, this is mostly in the nature of an attitude but, as we apply it, we find the principles assuming an increasing definiteness and reality. The most important of these broad principles follow:

The service of customers should be protected against training disturbance. To this end, operators should not handle customers' calls until carefully prepared.

The training of employees is one of the most important integral parts of management and supervision, not a detached special activity.

The training of an operator continues in coördinated steps throughout her period of employment.

Training for one job is subject to the same basic learning principles as training for another job. The conditions may differ, but the underlying principles are unchangeable.

Training should be based on facts wherever they are available rather than on opinion.

The training required by our employees presents an extensive problem in education and, as such, is subject to the fundamental principles of learning and teaching. No matter how much we draw on the field of education, however, we should remain practical telephone men and women.

With such an approach, there is no stopping point; today's achievement is greater than yesterday's but, more important, it points the way to further improvement tomorrow.

A Changing Scene

The initial training of present day operators is, first of all, carefully planned so as to help them learn the precise things their job requires in each case. What they want before all else is to become productive operators and that is made the major objective of this phase of their training. As now applied, this training bears but little resemblance to that of the past. Schools, classrooms, textbooks, and specialist instructors are vanishing.

The initial training has returned to the central office, where the operator's job is located and where the training was conducted in the early days of the industry. It is administered

with great care and under such control as to offer adequate protection to the service while producing more efficient training. The chief operator is now responsible for the training in all its phases and the instructor is one of the supervisors who is taking her turn at this important part of her job.* The central office management now has the same interest in and the same responsibility for a two-day girl as for a two-year one. An instructor works with two students throughout their initial training and helps them learn what they need in order to become operators.

Learning the Job

There are three major learning activities involved in the initial training: 1, discussions between the students and the instructors; 2, drills on certain operations to be learned; 3, practice operating. All this is done in the operating room, within sight of working operators. These three activities are not new in operator training, but the conditions and methods attending their application reveal significant changes. The discussions and drills are conducted at an unoccupied portion of the switchboard or, if none is available, in a corner of the operating room. The practice operating is done at regular switchboard positions among working operators, but with arrangements, described later, which provide the students with simulated practice calls to handle while protecting the regular service from interference. These activities are practical and informal, with the emphasis on meeting the needs of the students rather than on conforming to the routines of the instructor. Every opportunity is taken to render the learning easy, as for example, in the matter of technical language: If the student can handle the call, the fact that she cannot describe it is not made the occasion for correction and instruction. She is given ample latitude to correct her own mistakes and work

* A supervisor has direct supervision over the work of a group of operators, and a chief operator is in charge of the whole central office.

out her own problems and care is exercised to restrict her training to essential operations.

The job is learned as it appears to the operator at work, in the form of calls, and an attempt is made to avoid abstract learning, that is, learning things which the operator eventually will have to know but which are more difficult to learn separately and collectively than incidentally as adjuncts to individual calls. The operating parts of a switchboard position offer a good example: The essential things about these keys, signals, and cords can be learned separately in anticipation of handling any calls, but this learning will be much easier and more meaningful if it occurs only as each unit of this equipment is required for a specific call being learned.

The order in which the calls are learned receives careful attention. A certain call would be more difficult to learn if it preceded certain other calls than if it followed them. The determining factor in this case is ease of learning rather than the more obvious frequency of occurrence or sequence of handling the work. This is a matter of dual learning objectives: while learning the easier thing, the learner is automatically being prepared to learn the more difficult one. It could not be done, however, without facilities for controlling the practice operating.

A plan, or course, is used by the instructor as a guide, but it contains no lectures to be memorized and no lessons to be read to or by the students. It is addressed solely to the instructor for her guidance and is designed to stimulate thinking on her part as she meets the individual problems of her students. The successful use of this guide requires that the instructor know the particular job to be learned by the students, and also that she know how to teach. These two requisites, in fact, are more important than the guide. A separate course is prepared for each office, carefully adjusted to its requirements. There is no adherence to any of the self-contained teaching plans frequently used in vocational training but a flexible ap-

plication of fundamental principles, with emphasis on learning rather than on teaching.

Adjusting Training to the Actual Job

One of the greatest single advances in operator training has been the job analysis. This is a device which directs our steps toward precise facts and away from unnecessary assumptions, one which, alone, has greatly increased the efficiency of training. It provides for going to the switchboard and determining the exact nature of the job in terms of operations performed, before developing training plans for the office. The frequency of each operation is thus determined and it is then simple to decide with accuracy what to cover in the initial training. It is usually found that more than half of the operations may be omitted from the initial training and yet prepare the operator to dispose of over 95 per cent of the occurrences she will encounter. The resulting economy and increased training effectiveness where it really counts are obvious, but it is equally clear that it would be risky to prune the training tree except on a basis of facts.

Long Range Planning

The initial training cannot be planned to the best advantage unless the subsequent phases of training are also considered. The important questions regarding what to omit from the initial training can be answered intelligently only with a knowledge of how and when the operator can learn these things to the best advantage. In substance, all the requirements of the job—the things an operator must learn to do and the things she needs to learn about—are lined up beside a similar array of the conditions of the job which facilitate or limit training, in such a manner that they can be viewed from all angles. The development of a well balanced, complete training plan or any part of it then becomes a matter of carefully blending these two groups while applying the principles of learning.

The operations which occur in an office but are omitted from the initial training because of their infrequency are learned incidentally by the operators. As students, they are carefully trained to refer to the supervisor or an experienced operator any condition they cannot handle. This assures proper handling of these cases and the operators learn from each such experience, until they find themselves able to dispose of most of the conditions. An individual operator may never learn to handle some of them, however, because they occur so rarely. It is a matter of flexible individual adjustment, and the waste and futility of scheduling training for these conditions, to say nothing of expecting operators to handle them all, will be apparent. Experience indicates that, with a well balanced training plan, these operators' requests for assistance on cases they cannot handle do not place an excessive burden on the supervisor.

Learning When Learning is Easiest

Another productive innovation in determining the content of the initial training is sometimes called "training segregation." It is based on the fact that a girl can learn some of the more difficult operations of telephone operating more easily and quickly after she becomes an operator than while she is learning to be one. This is, in effect, a more advanced application of the principle which determines the scheduling of operations in a training course in the order of learning ease. After the operations which occur with sufficient frequency to be included in the initial training have been selected, they are carefully reviewed and those which present learning difficulties and which the new operator does not require immediately are withdrawn and scheduled for training several weeks after she takes up her work. The determination of whether she can work effectively without knowing a certain operation of this nature is on the basis of whether she can handle the condition by some other method already learned or can leave it to more

experienced operators to handle. This not only tends to restrict to expert operators the handling of these more difficult conditions, but materially reduces the obstacles encountered in becoming an operator. It happens frequently that, by the time the training of an operator is undertaken on one of these deferred features, she has already acquired a working knowledge of it, and of course, the omission of this operation from her initial training rendered that training easier.

Controlled Practice Operating

Practice operating has already been mentioned as one of the three major activities of the initial training. It is, in fact, considered the most important one of the three, for the operations performed are those of the job being learned. The practice positions are in groups of two, to accommodate the students of one instructor. These positions are working positions, occupied by regular operators during the busiest hours of the day and the training, consisting of discussion, drill, and practice, is scheduled so that the students practice a minimum of three hours each day during periods when the practice positions are not needed for regular operating. The two practice positions of a group are separated by two working positions which are occupied by experienced operators during practice periods. This arrangement places each student immediately between two experienced operators but no experienced operator has students adjacent to her on both sides. A third switchboard position, called a control position, is connected with the two practice positions of a group in such a manner that practice calls are originated and received by a special operator at the control position during practice periods. The practice calls are under the full control of this operator, who attempts to meet the needs of each student under the direction of the instructor. She not only has equipment for simulating calls, but also important special equipment, such as the control

device by means of which the student's telephone ear is developed.

The students, from their first morning in the operating room, practice intermittently among regular operators who are handling regular calls, yet the service is fully protected against inexperience and it is not necessary to impose any disturbing restrictions on them. They are given all the work they can handle at all times during practice periods and the instructor does not interrupt them for minor corrections or discussion. Here the students are learning by experience and the more work they handle during a given interval, the more experience it yields them. Thus a new operator of today accumulates much more working experience than formerly from the same amount of time devoted to practicing.

Easy Transition to Actual Work

When the students have learned enough about the work and have had sufficient controlled practice so that they can dispose of the ordinary requests of customers, they handle their first customers' calls. These calls are handled at the same switchboard positions at which they have taken their controlled practice, thereby reducing to a negligible quantity what was formerly a critical training step, both from the standpoint of the operator and of the customer. This operating is under the close observation of the instructor, who is ready to render any needed assistance but who again is very careful not to disturb the students unless necessary in order to protect the service.

Often we have no recollection of how we learned certain things even only a short time after learning them; the learning experience was so incidental and natural that the only impressions retained are of the things learned. This is particularly true of these students, who learn a great many things in this easy fashion as they spend their days in the operating room and practice their new work among their more experienced associates.

The training is planned to meet definite objectives of skill; each student is actually prepared to take her place as an operator. The duration of this training is determined in each case on the basis of how long it takes to meet the objectives efficiently.

How Well Does Training Train?

For determining the training needs of individual operators and the effectiveness of training plans, there is another fact-finding device, called the proficiency analysis. In applying this analysis, the work of the new operators, as they actually perform it, is revealed in terms of the quality and speed of essential operations. This appraising is done with the full knowledge and understanding of the operators and gives them confidence in the training attention they may receive subsequently, because they know it is adjusted to their actual needs. On this basis, also, training plans are continually being readjusted to conform more closely to the needs of operators and their jobs. Many improvements have been made with precision in this manner, the need for which would not even have been known in the absence of the proficiency analysis. In applying this analysis, those who design and apply the training plans are, in substance, making a critical examination of their own work; they are looking for what may be wrong with them rather than with the operators. This is not exactly a usual approach to a mutual problem, but it is logical and sound, and prevents self complacency, so detrimental to training.

Applies to All Classes of Employees

What has been said here about training applies generally to all classes of operating. These plans have already been adapted, in permanent or provisional form, to local operators in manual and dial offices, toll operators, information operators, and teletypewriter operators.

A projection of these plans leads to the training of supervisory employees on various levels and there is a direct relationship between the training for one level and that for the next higher level. But that is another story.

Where Specialists are Essential

Competent advisory staff specialists are just as important under present conditions as ever, and among the most vital accomplishments of the last few years has been the strengthening of the training staffs.

Efficiency

Without attempting to quote statistics, it can be stated on the basis of extensive measured experience that the present arrangements yield us a greater and better return for each dollar spent. The new operators are prepared for their actual jobs sooner—they handle more work efficiently from the beginning and progress more rapidly to the expert stage. Practice equipment costs, in general, are greatly reduced and much valuable floor space, formerly used for schools and classrooms, is being released to meet other requirements. Savings result also from the release of coaches, who functioned immediately after the initial training, and of specialist instructors, to other activities. The higher present instructor cost for each day of actual training, due to reducing the number of students trained by each instructor, is more than offset by the savings listed. Also, training costs which remained the same even when there was no training, such as floor space charges and training department instructor expense, are saved.

The fact that this evolution of training has occurred largely during a period when employment conditions have been such as to render a generally high grade of applicant available for telephone operating, has led to the question of whether the gains have not been largely due to the personnel quality factor rather than to improved training. This has been an important

aid; however, better training yields advantages to persons of higher caliber as well as to those less liberally endowed. Test groups of present day students, trained according to former training plans, have been compared with similar groups in the same offices, trained according to present plans, and the results have invariably shown to the advantage of the latter.

The Human Angle—Intangible but Predominant

The increasing participation of the supervisors and other management representatives in training activities is producing positive, wholesome reactions. The typical new operator of today performs her work with increased confidence, satisfaction, and enthusiasm which she, as an individual, has been helped to establish. She displays more natural interest and resourcefulness.

The various plans, methods, and devices discussed here are the obvious symbols of operator training—the terms in which nearly all of us think of it. They are the usual points of approach to this activity and, as has been stated, reveal interesting and rather impressive recent gains. But in considering our training progress on the basis of significance of accomplishment, we see these familiar outstanding factors more as results than as causes. The results may be favorable and attractive but the truly important thing is what caused them. What is it that underlies this progressive improvement which finds final expression in such terms as skill, time, and dollars? The answer to this question has to do with people rather than routines and facilities. The most far-reaching element contributing to present day operator training advancement unquestionably is found in the steadily expanding knowledge of supervisory and staff employees in the fundamentals of the whole problem. This basic changing of individuals is so natural and gradual that it would not be likely to attract general attention, but it is both real and potent.

HENRY C. LACHANCE

The Bell System Presentation to 1939 World's Fair Audiences

I. The Golden Gate International Exposition

STEP the calendar ahead a few weeks. Come with us to Treasure Island in the center of San Francisco Bay, where the Golden Gate International Exposition will be held from February 18 to December 2, 1939. Your first impression is typical of that received by every visitor: a breath-taking view! From the level expanse of this 400-acre island you see a magnificent skyline of cities and hills, dominated by the two greatest bridges in the world: the 77 million dollar San Francisco-Oakland Bay Bridge, longest and most costly anywhere; and the 33 million dollar Golden Gate Bridge crossing the harbor entrance with the longest single span ever created.

Come with us to the Bell System Exhibit. But first stop and contemplate the Exposition as a whole. Styled "A Pageant of the Pacific," 11 Western states are its sponsors and 36 foreign nations are participating. Its cost is estimated at 50 million dollars, including the expenditures of hundreds of industrial exhibitors.

One of the many miracles of this Western World's Fair is its site, which may be accurately described as the largest man-made island in history. This sizable bit of terra firma was built by dredgers from a natural depth of from two to 26 feet below water level to its present elevation of 13 feet above the tides. Located about four miles from downtown San Francisco and some seven miles from the center of Oakland, the island is remarkably accessible. Key to this ease of transportation is a broad causeway for six lanes of highways leading across near-by Yerba Buena Island to the Bay Bridge.

Background of Pageant festivity are the massive and stately exhibit palaces, windowless for uniformity in display under constant illumination. A New "Pacific" style of architecture was evolved for these buildings, blending ancient Oriental forms with Mayan, Incan and Cambodian treatments. The result is a compact grouping of unified simplicity. An ancient walled city is the basis of the Exposition's structural scheme. The main exhibit group comprises six great blocks of halls, spaced by broad courts from the central Court of Honor, and providing about one million square feet of exhibit space.

At night, Treasure Island becomes a magic city in amber, white, and pastel shades of shimmering light, apparently floating in the waters of the harbor. For the first time, a world's fair will be indirectly lighted throughout, not a single light source being visible to the eye. Illumination facilities include thousands of floodlights and fluorescent tubes, which reach new heights of efficiency in green, blue, pink and amber; ultraviolet floods; under-water lamps, and gigantic cylindrical lanterns.

The Exposition is equally colorful in the daytime, when the beauty of the buildings and courts is complemented by plantings of more than 4,000 trees, 70,000 shrubs and literally millions of flowering plants. Landscaping has been governed by considerations of color and exposure; separate courts of the elaborate architectural plan are given separate color schemes, carried out by the bloom or foliage of all vegetation.

The Bell System Exhibit

The Bell System Exhibit is located in the northeast corner of the Palace of Electricity, where it occupies about 7,500 square feet of space. This exhibit area is enclosed on two sides by walls of the Palace, and on the other two sides by its own walls 15 feet in height. The exterior surfaces of these latter walls are decorated with photomurals of telephone significance.

Two principal entrances to our exhibit enclosure are from the center corridor of the Palace, and a secondary means of access opens from the Court of the Seven Seas. Choosing to enter through the Palace, we find ourselves in a building within a building. A building, we might say, which "seems like home" to telephone people. There is something about it that would say "Bell System" to us—even if there were no signs to identfy the exhibit. And within are the results of Bell System research.

Long Distance Demonstration

Immediately, our attention is focused on a large brilliantly-illuminated map of the United States. Fifteen hundred small lights, burning dimly, represent as many cities, distributed more or less uniformly over the face of the map. Directly in front of the map a young woman sits in plain view at the "map-control board." On either side of the map is a glass-enclosed booth, from which demonstration long distance calls are made.

The space immediately in front of the map operator's position is enclosed, except for an entrance, by two counters, extending from the booths toward the center of the room. About ten feet in front of the counters is a horseshoe-shaped desk whose attendants are responsible for scheduling and assigning visitors to the toll call booths. On either side of the "horseshoe" are four oblong counters which, together with the two counters back of the map operator, accommodate some 125 telephone receivers for listening to demonstrations of long distance calls.

Audience Participation

The actual operation of this long distance exhibit furnishes the best reason for its existence. People like to participate actively in any demonstration, and to learn by actual experience. Thus, by taking advantage of this universal propensity,

we are, in this case, afforded an excellent opportunity to show dramatically the simplicity of placing long distance calls.

A person desiring to place a call to any listed telephone in the United States, served by the Bell System or other companies, need but apply at the demonstration application desk. You do so, and are given a card on which you write your name, and the name and telephone number of the person you desire to call. The card is stamped with a number, and you retain its stub. The application clerk selects a ping-pong ball inscribed with your number and places it in a chute which carries it into a large glass bowl. At about half-hour intervals, a drawing is held, and several balls—usually six or eight—are taken from the bowl.

Illuminated signs indicate the numbers selected and request the winners to apply at the scheduling desk for appointment cards giving them their turns for placing demonstration calls.

When your turn comes—assuming you were selected by the ping-pong ball device—your number appears on an illuminated indicator and an arrow points automatically toward the booth you are to occupy. While a call is in progress in one booth, the visitor next in turn is ushered to the other of the two booths so as to be ready and waiting. In this way, calls are kept continuously in progress.

Once in the booth, you wait until the operator illuminates a sign telling you to go ahead. You take the handset from its cradle and place your call. While the long distance connection is being completed, your fellow visitors watch a chain of lights dart across the big map, illustrating the route of the call. The lights flash while your called party is being rung and then burn steadily and continuously until you have hung up. Oh yes, and while you were talking, perhaps a hundred persons were listening to your conversation! And that one novel touch is the only thing that made your demonstration call different from the ordinary long distance call, when none but the person at the other end of the line hears what you have to say.

The audience in the demonstration room is kept posted on the various time intervals of the call through four vertical thermometer-like rows of electric lights. One row shows the time elapsing from the time you take up the telephone until the operator has taken the details of your call. The second row indicates the time required before the called telephone rings. The third row tells when the called number answers; and the fourth when the desired person is on the line.

In every demonstration, the operator explains to the called person that the call is originating from our Bell System Exhibit at the Golden Gate International Exposition and that many visitors will be listening to the conversation. All of the demonstration calls are person-to-person calls. The average conversation will be less than three minutes in duration. A maximum of three minutes for each call was chosen to insure that as many persons as possible may participate, and that each person who calls may have a sufficient time for a satisfying conversation.

When a call is made to a non-Bell telephone, connection is established through the courtesy of the telephone company operating in that area, under arrangements endorsed by the United States Independent Telephone Association.

Created by Bell Telephone Laboratories

It can readily be seen that this demonstration provides an educational and entertaining show, not only for people who place calls and listen in, but also for those who do not wish to take time to participate. The same can be said of the scientific displays—of which more later—in the Bell System exhibit: they are interesting and understandable to everyone. This result has been attained through many months of planning, experiment and work by the personnel of Bell Telephone Laboratories and The Pacific Telephone and Telegraph Company. Conception of the exhibit is credited to John Mills, Director of Publication for the Laboratories. The conception involved

the use of developments to be made by the scientists and engineers of the Bell Laboratories; and these developments have been coördinated into a practical working exhibit under M. B. Long, the Laboratories' Assistant Director of Publication.

Each of the exhibits is really a communication system and involves contributions from the Laboratories' Research Department, its Apparatus Development Department and its Systems Development Department. There were many problems of design and of acoustics to be considered and these were handled under the immediate supervison of R. E. Cushman, who was also responsible for engineering the installation of the Voder at San Francisco. Apparatus involving new principles had to be developed for reliable operation twelve hours a day throughout the period of the exposition. The newly developed apparatus had also to be coördinated into a practicable working system with supervisory and control equipment. Much of this system's development work for exhibits was carried by L. P. Bartheld, one of the members of that department concerned with trial installations. And it is under his general direction that equipment is now being installed by J. M. Edwards of The Pacific Telephone and Telegraph Company and a crew of technical men associated with him.

Solution of "on the job" problems of engineering and decoration have been aided by plans suggested by J. R. Leed of the Chief Engineer's Department in the Northern California Area, and by R. D. Berry of the Administration Department, respectively. The operation of the exhibit will be under the general supervision of A. L. Littig, Vice-President and General Manager, Northern California and Nevada Area; and the writer will be in direct charge as manager.

The Voice Mirror

The opportunity of hearing your voice as others hear it is provided by a Voice Mirror, which, if experience at other expositions and fairs is duplicated, will prove exceptionally popu-

lar with visitors. This ingenious demonstration enables you to talk for an interval of five seconds and then listen while the apparatus repeats what you have said. Extra receivers are provided to permit a number of people to listen to the performance. Four or five visitors a minute can participate in this exhibit.

Hearing Test

In the southeast corner of the exhibit area is located a sound-proof structure in which will be conducted hearing tests. This structure stands on its own foundation and has no contact with the rest of the building except for a cork fill in the two-inch gap which separates its floor from the floor of the rest of the exhibit area. It is built with double walls, with acoustic insulation between them; and its roof is similarly constructed. A ventilating system supplies it with fresh air from a blower but the conduit through which the air flows is also carefully constructed of acoustic material, with acoustic baffles inside and with flexible joints so that no outside noise can be transmitted through the conduit. Entrance and exit are through sound-proof doors. Next to the entrance itself is a counter where attendants can give instructions to those visitors who wish to test their own hearing. Passing through the entrance, one finds an acoustically-treated reception room from which sound-proof doors lead to three inner rooms. In each of these are seven booths to permit seven visitors at a time to participate in a hearing test.

One of the inside rooms is wired for a test of hearing using spoken words; another for a test using musical tones; and the third room can be used for either test, depending upon which finds greater public acceptance. The word test is similar to that presented at the Dallas Exposition in 1936. A participant is given a printed form and seated in a booth. He listens through a telephone receiver to the spoken instructions. He is told that he is going to hear numbers, two at a time, as for

example "seven four"; and that successive pairs of numbers will sound farther and farther away until so faint as to be practically unrecognizable. He writes the paired numbers which he hears in a column; and then repeats the process listening to a different set of numbers. Printed instructions tell him to hold the sheet to the light; visible to him, then, heavily printed in reverse, are the correct numbers which he should have heard. He checks in each column the last pair of numbers which he heard correctly. Each column contains eleven pairs of numbers, starting with a loudness sufficient to be easily recognizable and decreasing until just intelligible, on the average, to youths of normal hearing. If his errors occur in the early part of the column his hearing is obviously seriously impaired; if about the middle, slightly impaired; but if not until near the end, his hearing is good or normal. "Normal," as here used, means average for young persons of good hearing; the human ear, of course, like the human eye becomes less sensitive as years advance.

In the test using musical tones, there are five columns on the test sheet and for each column the participant listens to a different pitch of a pure musical note. He starts by hearing a loud tone of pitch corresponding to "A" above middle C on the piano, sounded two or three times in short succession. He is asked to write down the number of times he heard this tone. Then, as in the other test, he is told that he will next hear the tone as if from farther away and so appreciably weaker. The tone is sounded again and he writes the number of spurts of tone that he heard. So the test proceeds with groups of tones, each time fainter until so faint that only a normal youthful ear can recognize correctly how many times the tone sounded. After completing the test for that tone he starts on the next column, hearing a tone an octave higher. Expressed in cycles per second, the tones to which he listens are 440, 880, 1760, 3520, and 7040—the last well above any which he would receive in ordinary radio broadcasting. Printed in reverse on

the back of the test card are the numbers which he should have recorded. He checks his card as before, and now has a record showing the acuity of his hearing for various pure tones throughout the most important part of the hearing range. If the visitor is over forty-five, he may find that his hearing is slightly impaired for the higher pitches.

The Voder

In the southwest section of the exhibit area is a large enclosed space which will house the unique feature of the exhibit: an electrical voice organ which was developed by Bell Telephone Laboratories to be an exhibit at the San Francisco and New York expositions. Early in its development it received the nickname of "Pedro, the Voder," because it is intended to be a "*V*oice *O*peration *DE*monstrato*R*."

The Voder manufactures speech. There is a small table with a dozen keys, looking somewhat like those of a piano, a foot pedal, and a bay of apparatus containing vacuum tubes, coils, and electrical filters. The control of its electrical circuits is through the keys and pedal. The current, corresponding in character to the position of the keys, goes to a loudspeaker and from this loudspeaker comes intelligible speech when a trained operator manipulates the keys.

At the time plans were being considered for the Bell System exhibit, there were available in the Laboratories some important and interesting results of researches carried out by Homer W. Dudley, a member of the Laboratories' technical staff, on the electrical analysis and synthesis of speech. His researches, which were undertaken as part of some of the Laboratories' fundamental investigations—looking towards telephonic problems of the future—pointed to the possibility of making an electrical instrument which would be analogous to the human vocal mechanism. Mr. Dudley undertook the task of applying his researches to the production of a model of such a device

and produced a remarkable, ingenious, and eloquent mechanism. The Apparatus Development Department of the Laboratories then undertook the development of this model into an instrument suitable for continuous operation in an exhibit.

The auditorium for the Voder was especially engineered by the Electrical Research Products Incorporated and is the last word from the standpoint of acoustical treatment. The Voder is on a platform; its loudspeaker some eleven feet above the floor; and its voice seems to come from a futuristic head painted on the wall. This decorative design was an individual contribution of Mr. Berry, who also was responsible for the color scheme of the walls of the exhibit area.

As you enter this room you see a young lady seated at the instrument and beside her is an announcer who explains in brief the principles of the instrument. He then asks the young lady questions and she plays out the answers for you with her fingers.

The young ladies who demonstrate this unique feature will have had nearly a year's intensive training in New York under S. S. A. Watkins, a member of the technical staff of the Laboratories. Because Mr. Watkins was the only man in the world who was proficient in making the instrument talk, it has been necessary to select and train in New York all of the operators for both the San Francisco and New York expositions.

In order to give a clear conception as to how the Voder operates, it might be well to describe a test which Mr. Watkins set up to determine the aptitude of young ladies for playing the machine. The young lady was first seated at the machine and then asked to drop her fingers on all the keys at one time. The result was simply a loud noise which was probably about the equivalent of what one would expect to receive from the vocal chords if there were no head on the body with cavities to act as resonators. She was instructed to play separate keys until she found one which sounded like the vowel E. She was then

asked to hold this key down and then play other combinations of keys to get one which used in conjunction with that one would sound more like E. Having found E, she was then requested to raise her forearm from its arm rest, changing the factor of the keys from vocalized to breath sounds. She was then asked to manipulate the keys until she found a combination which sounded like the breath sound CH. She then had the E and CH. Next she was told to depress the keys which made the sound E and to place her foot on a foot pedal and raise the pedal up and down. She then got a rising and falling inflection of the vowel E. She was then told to play E (rising and falling inflection) CH. This gave her the word EACH.

It can readily be seen that the instrument has not been an easy one to master, as to produce finished speech on the apparatus requires not only a sense of rhythm, a fine touch, a good ear for speech sounds, but also a very perfect synchronization of feet, hands and arms.

Exhibit a Product of Research

All of the demonstrations in the Bell System Exhibit on Treasure Island are the direct outgrowth of research and development work of the Bell System, or are adaptations of equipment and methods employed in rendering telephone service. The objective and ideal of the Bell System is to improve its facilities and methods to insure that the public will receive the best possible service, anywhere and at any time. The Exhibit is designed to emphasize these facts, by affording people an opportunity to do something they like to do, through the use of the familiar telephone instruments which play such an important part in their daily lives. Thus, the Exhibit is a service to the public and, as such, fills a definite need in carrying the story of telephone progress to thousands of people in all walks of life.

L. N. Roberts

II. The New York World's Fair of 1939

ON April 30 the New York World's Fair of 1939 opens its gates to the public. Its architecture impressive; its park-like landscaping beautified by magnificent pools and artistic fountains; and its illumination at night made unique by lighting effects in advance of anything thus far seen, this great exposition will be colorful, exciting, memorable. Portraying man's achievements of the past, it points his imagination toward "The World of Tomorrow." The number of governments, institutions and businesses participating will be the largest in the long history of World's Fairs. The Fair management estimates that attendance during the six months of 1939 will be in excess of 60 million, a number equal to one-half the population of continental United States and three times the attendance during the first year of The Century of Progress at Chicago.

The visitor, arriving by the Long Island Railroad or one of the principal subway routes, enters the grounds and, walking a short distance along one of the main highways toward the Fair's Theme Plaza, comes to the Bell System Exhibit building. Located on a lot three and one-half acres in size, this fine building is landscaped by spacious gardens and the inviting coolness of a grove of pine trees. The southern boundary of the lot forms a portion of the periphery of the Theme Plaza, where are located the Trylon and Perisphere as the central point of the Fair.

Our visitor turns into an inviting path through a garden and arrives at one of the main entrances to the building. Entering, he finds himself at the rear of a large room taking in the entire end of the building, where a show is in progress. It is the Demonstration Telephone Call. Directly opposite the doorway he sees an escalator leading to a balcony, which is in reality a mezzanine some 18 feet in width. This attracts him

and upon reaching it he is at a fine vantage point to observe what is going on below him.

Long Distance Demonstration

Across the room is a huge map of the United States, 45 feet wide, with 3,500 small lights marking important cities and towns. On its surface are shown the principal rivers and mountain ranges and the states in faint outline. The side walls of the room contract slightly from the rear toward the map. On each side of the map and almost under it, is a circular glass-walled telephone booth in which participants sit while making their demonstration calls. Located near the map are luminous "thermometers" twenty feet in height by means of which are indicated the time it takes for the demonstrating visitor to give the details of his call to the toll operator, the time until the called telephone is rung, the wait until it is answered; and finally the time to get the particular person and start conversation. On the main floor, in front of the map, are tables with head receivers for 200 visitors at a time to listen in on the conversation. At the side is an application desk where are filed applications for participation. In view of the fact that only 6 or 7 can be accepted for each half-hour—from perhaps a hundred who apply—there is a device to select impartially those who are to talk. To each applicant is assigned a serial number and a similarly numbered ping-pong ball is deposited in a large glass globe visible to the audience. When the applications are all in, the balls are agitated by a blast of compressed air until 6 or 7 run down an outlet tube. The lucky applicants are those who hold corresponding serial numbers; and they are then conducted in turn to the booths where their calls are completed. The 3,500 small lamps with which the map is studded glow constantly in only partial brilliance; but when a demonstration call is made, a row of lights indicating its route from New York to the called city is brought to full brilliance, to remain so.

during conversation. There then appears in an appropriate position on the map the name of the called city spelled in large luminous letters.

As our visitor on the balcony looks down upon the activity around the application desk, the novel ping-pong lottery, the luminous "thermometers," the demonstrating visitors being conducted to booths by pages, the crowd at the tables where listening receivers are located, and the constantly changing indications on the map surface, there is before him an intriguing scene. The effect is much like that which he experiences when in attending the theatre a play unfolds before him.

Calls from the Demonstration Exhibit are handled at the Long Lines toll office at 32 Sixth Avenue, New York. They are accepted to any listed telephone in the United States. When a call is to a non-Bell telephone, connection is established through the courtesy of the telephone company operating in that area, under arrangements endorsed by the United States Independent Telephone Association.

It is obvious that the demonstration would not be so conclusive if it consisted only of calls made by telephone people to telephones selected by them. Instead there has been made available the opportunity for visitors at the Fair to call any listed telephone anywhere in the United States. This means, of course, that both the calling and called parties coöperate with the Telephone Company in demonstrating its service by publicly making a call to which others can listen. It is a favor on the part of the public in return for the chance to make a call. This demonstration of the speed and quality of our service departs from standard operating practices only to the extent that just prior to the start of conversation the called party is notified that he is to talk with someone who is calling from the Telephone Exhibit at the World's Fair grounds and that other people will listen in on the conversation. This notification advises him that in this respect the call is variant to the privacy of normal telephone conversations and at the same time pub-

licly recognizes his assistance and that of his friend in making the demonstration possible.

The Voder

Leaving the Demonstration Call Room, our visitor continues along the balcony as it swings around a large circular area over 80 feet in diameter and finds a vantage point about half-way around this room. This is the exhibit space for the Voder, a recent development of Bell Telephone Laboratories and one of the new features in Bell System exhibits. At the balcony level large windows extend around the outer wall, from which one may look out to the grove of pine trees and the Theme Plaza. The windows slope inward from bottom to top, while the side walls under the balcony slope outward from top to floor, and, in addition, are of fluted, convex structure. It is much as though large cones were cut in two lengthwise and placed side by side with the points under the balcony and the bases resting on the floor.

This V-shaped arrangement of windows and walls above and below the balcony is acoustically essential for the successful demonstration of the Voder. The windows drive the sound waves striking against them down onto the carpeted floor of the balcony and the sloping, fluted side walls below force them up against the under side of the balcony which is treated with acoustic materials. The purpose of this arrangement is to prevent the focusing of echoes such as occurs in whispering galleries.

As our visitor stands at the mid-point of the balcony, directly across the room from him is a platform extending out from the opposite wall, on which is the Voder. This is somewhat larger in size than an ordinary card table; and on its surface are 14 keys similar to those of a pipe organ, a few partially concealed switches and three small knobs. There is a rest for the right arm, a wrist-bar under the control of the left wrist and a foot pedal screened by the desklike construction of the console. At

the Voder a girl operator is seated and beside her stands an interlocutor. Both Voder and microphone are connected to a loudspeaker. The Voder itself is an assembly of telephone apparatus for producing synthetic speech and the demonstration of this phenomenon, which is a dialogue between the man and the operator, tells our visitor how it works.

When the keys are pressed down, there is produced a sound similar to that which would issue from the larynx if there were present no throat and mouth cavities such as are used in forming human speech. Played by various combinations of keys, sounds resembling the vowels issue from the loudspeaker and following this a number of consonants are spoken. It is shown that these sounds may be made in the tone of full speech or as though whispered, depending upon whether the operator depresses the left hand wrist-bar in the case of the former, or allows it to remain in normal position in the case of the whispered sounds. Having demonstrated these fundamentals, the man at the microphone asks the operator to combine vowel and consonant sounds into short words and as she does so those words issue from the loudspeaker, clearly and intelligibly. Simulation of the human voice is completed by the operation of the foot pedal which raises and lowers the pitch. From this point on longer words are formed syllable-by-syllable, then put together in whole and as a further step they are included as words in sentences. The remainder of the demonstration is a dialogue between the man at the microphone and the operator answering through the Voder. The program lasts about five minutes and at the end starts in again on its repetition. This demonstration of the illusion of the human voice, produced solely by the manipulation of apparatus controlling electrical circuits common in telephone use, is a lively and interesting show. Our visitor has seen and heard something new in the advance of scientific understanding of human speech. Already a substantial contribution, it will play its part in telephone research and engineering.

VODER AN OUTGROWTH OF FUNDAMENTAL RESEARCH

The Voder is a synthetic speaker doing electrically what one does in talking, by controlling through keys sources of sound corresponding to vocal cords and breath. It was an outgrowth of fundamental researches in telephony carried out by Homer W. Dudley in Bell Telephone Laboratories in his study of electrical analysis and synthesis of speech. When the World's Fair exhibits were being planned it was suggested that a synthetic speaker could probably be developed by applying the results of this research and Mr. Dudley undertook that work, producing the first model of the Voder. There remained the problem of how to make it talk and to develop suitable equipment for an exhibit. This further development was undertaken by the Apparatus Development Department of the Laboratories. Mr. Stanley S. A. Watkins assumed the difficult task of developing its language. First he learned to operate it himself, applying to that end various research results of the Laboratories and a keen appreciation of speech sound. Then he developed a course of instruction and a technique for selecting and training operators.

Learning to operate it was obviously working in and with the unknown. The immediate problems were the construction of speech sounds, the development of finger technique, acquiring skill in pitch variation and, finally, proper timing. In addition, it was essential to insure that the motion of the finger keys and other controls should be sensitive and consistent. Mr. Watkins relates that when he first thought he had acquired the ability to make the Voder say "yes" and was exhibiting it to someone, his listener thought he was saying "peanuts." That was indeed a challenge.

After having learned how to make most of the sounds used in the English language, the next step was the development of a course of instruction. This involved, as a preliminary, considerable language research to select a useful vocabulary which the Voder could quickly utilize.

Having developed a language for the Voder and a course of instruction based on that language, the next step was the selection and training of a group of demonstrators. It was decided to recruit this group from Traffic Department operators. Since operation of the Voder is entirely different from that of any musical instrument, two qualifications are indispensable. They are finger dexterity and an ear sufficiently critical to analyze speech sounds on phonetic lines. It must be remembered that widely different sounds are sometimes made on the Voder with similar finger combinations, the only difference being in the technique of depressing the keys. About 350 traffic operators from the New York Telephone Company and the Long Lines Department were given tests and of these 24 were selected for training. By the time the Fair opens they will have been in intensive training for a year and the seeming ease with which they go through the demonstration will give but scant intimation of the task of preparation.

The foregoing recital of Mr. Watkins' work gives but a fragmentary idea of the fact that it has been outstandingly pioneer. When he started with the Voder it was an unknown. He has taken a theory and made it talk. For several months he has had the assistance of Mr. Dick P. Fullerton, Jr., transferred from the Western Electric Company to the New York Telephone Company. Mr. Fullerton has been helpful in the training program and invaluable in keeping the twelve practice Voders in the school at a high degree of operating dependability. Without his contribution, the program of bringing this project to successful issue would have been seriously impaired.

Hearing Tests

At the conclusion of the Voder demonstration, our visitor leaves the attractive room in which it is staged. Continuing a short distance he sees across from the balcony, a glass enclosed sound-proof room with aisles leading to fifty-six special telephone booths for individual hearing tests. In these booths are

given one of two types of hearing tests, that is, by the use of pure tones transmitted from a phonograph mechanism through telephone receivers. By this means visitors may test the acuity of their hearing by listening to pure tones which gradually decrease in loudness until they are scarcely audible. In order to make the test interesting to those who do not participate and easier for those who are going to take it, a convenient principle of showmanship is utilized. Over the booths, opposite the balcony, and also visible from the main floor below, our visitor sees a small stage equipped with microphone and public address system. A girl demonstrator is seated on the stage. She is presumably taking the same test as the people in the booths below and what she is hearing in her receiver is audible through the public address system to those of the balcony and the floor below. A large test card similar in design to those used by participants in the booths appears on a screen beside the stage and is filled out as the test comes over the loudspeaker. This description test provides a show of two or three minutes duration for our visitor and at the same time gives him easily understood instructions in taking the test should he desire to do so.

A Stereophonic Demonstration

Further along on the balcony our visitor finds himself looking down onto a large room similar in size to the one at the opposite end of the building where he saw the Demonstration Telephone Call. At the end of the room across from him there is a formal garden of paths, hedges and flowering plants, about 25 feet deep and extending from side wall to side wall. The garden slopes up to a terrace at its rear on which our visitor sees seated in garden chairs six persons who are engaged in conversation. All that they say is plainly heard through concealed loudspeakers. From what they say, however, he recognizes that one of them is a member of the Exhibit Staff who, as host, is engaging the rest in brief, informal conversation. After

a couple of minutes of this friendly visiting, the host conducts his guests down the garden path where they rejoin the audience on the main floor. Meanwhile, the floor of the terrace on which they were seated has been moving sidewise, carrying the vacant chairs out of sight of the audience and bringing into view a similar arrangement of chairs in which there are seated mannequins—store window dummies—corresponding to the visitors who have just left the terrace.

All that the visitors and the host have said is now repeated through the loudspeakers; and this reproduction is stereophonic so that the reproduced sounds appear to come from the same place on the terrace as they did originally. What the woman who was seated in the second chair happened to say is heard just as though it came from the mannequin now occupying her former place. The reproduction is complete both as to tones and loudness and as to spatial relationship. What the terrace's former visitors hear is therefore a complete reproduction of what they said; and they hear themselves exactly as others heard them, to mutual amusement with the audience.

When the reproduced conversation has been completed the platform of the terrace slides back to its former position bringing into view again the original seats but now they contain five new visitors. And so, in groups of five, selected visitors have the opportunity of hearing themselves in complete and natural reproduction. The guests each time are selected, from those of the audience who wish to participate, by an ingenious lottery device formed by an adaptation of step-by-step dial equipment. This arrangement was developed in the Laboratories by Mr. L. P. Bartheld of its Systems Development Department. He also assisted materially in other electrical features of the exhibit, notably the Demonstration Telephone Call.

This new acoustical Exhibit which makes its bow to the public at the New York World's Fair of 1939 has the binaural, or stereophonic feature of the famous Oscar show of the Chicago Exposition of 1933; but it is a marked extension of that early

exhibit. Looked at in one way it is a mass production of auditions, offering to seven or eight hundred visitors a day opportunities to hear their voices reproduced with remarkable acoustical fidelity. To the audience the show has something of the characteristics of an " amateur hour " with its constantly changing succession of actors.

Technically this Exhibit is remarkable for the stereophonic public address system which amplifies the words of the participants; and for the recording and reproduction stereophonically of what the participants say. These technical developments are the application of fundamental researches in Bell Telephone Laboratories which have been carried out under the direction of Dr. Harvey Fletcher and with important technical contributions by Dr. E. C. Wente.

The complete stereophonic transmission and reproduction of sound was first demonstrated to the public in 1933 before the National Academy of Sciences at Washington. The stereophonic binaural public address system was first utilized in the Rose Bowl at Pasadena, California, a couple of years later. For this exhibit, however, there was required the stereophonic —two channel—recording of sound and its faithful reproduction. This was accomplished by using a magnetic tape method developed by Mr. Wente and his associates.

In these research developments of the Laboratories it was early recognized that there was the possibility of a striking Exhibit at the New York World's Fair of 1939. There remained, however, many unsolved technical problems in connection with the pickup, recording and reproduction of sound and in the acoustical conditioning of the Exhibit space. Tape recording equipment needed to be developed to handle two telephonic channels in perfect synchronism and to operate reliably for 12 hours, seven days each week of the Fair. The many technical problems of apparatus development and acoustical conditioning, installation and operation have been successfully handled by members of the Apparatus Development Depart-

ment of the Laboratories under the direction of Mr. W. A. MacNair. In the design of the acoustical treatment of the space, engineers of Electrical Research Products, Inc., cooperated. These same engineers were also responsible for the very difficult acoustical problems presented by the Voder space.

The "Hall of Pioneers"

Our visitor, continuing along the balcony, on the opposite side of the building by which he reached the acoustical exhibit just described, comes to a space where the balcony has been widened to a large room of circular shape. It is designated "Hall of Pioneers" in honor of telephone pioneers past and present. At the center of the room is a Voice Mirror with capacity sufficient to permit several thousand visitors a day to hear their voices as others hear them when they telephone. Around the walls of the room are several exhibits of historical and modern equipment and also apparatus of scientific significance, so that those attracted to the progress of communication by telephone will find many features of interest. On the main floor, in the space underneath this Hall of Pioneers, there are two exhibits: another Voice Mirror and a small model of a panel dial unit. Although this unit is only about five feet in length, it shows the operation of the equipment which is utilized in connecting a calling telephone in one office to a called telephone in another office. It shows also, the operation of a message register. The equipment is so condensed that visitors can get close enough to follow its operation easily. As an attraction of further interest they may trace the progress of calls which they dial themselves. The model dial unit was originally developed by Mr. W. R. Daniels, Supervising Instructor in the Manhattan Plant School of the New York Telephone Company, for use in Open House Demonstrations.

A short distance beyond the Hall of Pioneers, our visitor looks down upon a second group of fifty-six special telephone booths, where hearing tests are given by use of words trans-

mitted, as in the case of the tones test, from a phonograph mechanism through telephone receivers. This test also has its small stage occupied by a girl demonstrator.

In passing this exhibit our visitor returns to the point at which he reached the balcony to start his tour of the building. He has seen seven exhibits, the Demonstration Telephone Call, the Voder, the Hearing Test for Tones, the Stereophonic Audition Exhibit, the Voice Mirror, the Equipment Exhibit in the Hall of Pioneers and the Hearing Test for Words. The eighth is the Model Dial Unit. All these exhibits employ apparatus and techniques which either are adaptations of the equipment and methods employed in telephonic service, or are outgrowths of its acoustic studies. There are no importations of entertainment or attractions foreign to the telephone field.

The Unique Importance of the Balcony

Had the visitor so desired he could have descended at any time to the main floor and participated in all the exhibits except that in which the Voder is demonstrated. This opportunity to become a part of what one has come to see follows a sound principle in showmanship and will give our exhibit wide popular appeal.

The provision of a balcony from which those not desiring to participate may view the exhibits, is a distinctive feature. From this vantage point our visitor, whom we accompanied on his tour, looked down upon exhibit after exhibit in which the participating visitors made a show within a show. In contrast to having been on a moving platform, or subject to some other means of slow transportation, our visitor while on the balcony could regulate his progress to suit his own desires, pausing where and for as long as he wished. But wherever he looked to the floor below, something of interest was going on which he could see, hear and understand.

The development of a plan for a Bell System exhibit presents a problem which if answered correctly will add to the prestige

of the System and if answered poorly will detract from it. It is significant that at The Century of Progress in Chicago and subsequently at the smaller expositions in San Diego and Dallas, the Bell System exhibits were largely attended and well received. It is convincing testimony that the value of what is appealing to a World's Fair crowd was correctly gauged in these three cases. The philosophy of those telephone exhibits was developed by Mr. John Mills of Bell Telephone Laboratories, and in its more complete form has been applied to the New York exposition, for which he suggested the main features. His plans also included the added attraction of the balcony as indispensable to superior showmanship.

In all this work on World's Fair Exhibits, Mr. Mills, who is Director of Publication in the Bell Telephone Laboratories, has had the collaboration of Mr. M. B. Long, Assistant Director of Publication. To Mr. Long has been delegated each time full responsibility for the necessary technical developments and for their coördination into a smoothly operating exhibit. The size and complexity of the exhibits at New York has presented a wide range of difficult problems, all of them technical, some of them aesthetic and others of an operating nature. In their solution Mr. Long's judgment has been unerring with the result that the presentation of these exhibits will be artistic, appropriate and easily workable.

Arrangements Within the Exhibit Building

The building in which the exhibit will be housed is a large, imposing structure, irregular in shape, about 350 feet long and over 100 feet in width. Its interior arrangement is such that it is in reality a series of six small theatres, with their foyers contiguous and having the added feature of a continuous balcony. The decorative scheme of Venetian red and French gray is distinctively attractive. Owing to the fact that the exhibit is entirely acoustical in character, the main and balcony floors are completely carpeted as a precaution against sound

distortion. The carpet is of a color and pattern harmonious with the decorating scheme. As the visitor moves from exhibit to exhibit through the building he will be impressed by the dignity of its proportions, its structural arrangement and its attractive decoration. The many problems involved in supervising the erection of this large building with its special arrangements and facilities have been handled with architects and contractors by Mr. J. H. Gordon, Jr., Chief Engineer of the Long Island Area of the New York Telephone Company, and his associates.

There is a wing to the building which contains, on its main floor, offices and service quarters for the operating personnel. On the second floor, reached from the balcony level at the Hall of Pioneers of America, there is a large and attractive Lounge for Telephone Pioneers, their families and friends. It is hoped that Pioneers will make use of this Lounge for relaxation and as a meeting place with telephone friends, and it is hoped that members of the Bell System family who happen to have less years of service than those of Pioneers will also use this Lounge to which they are invited.

The exhibition of the telephone to World's Fair audiences had its origin in the presentation of the infant telephone by Dr. Alexander Graham Bell at the Centennial Exposition held in Philadelphia more than sixty years ago. Among the exhibits since that time, this one at New York will be the most comprehensive. In it the telephone art will be set forth as an achievement of today and an augury of tomorrow.

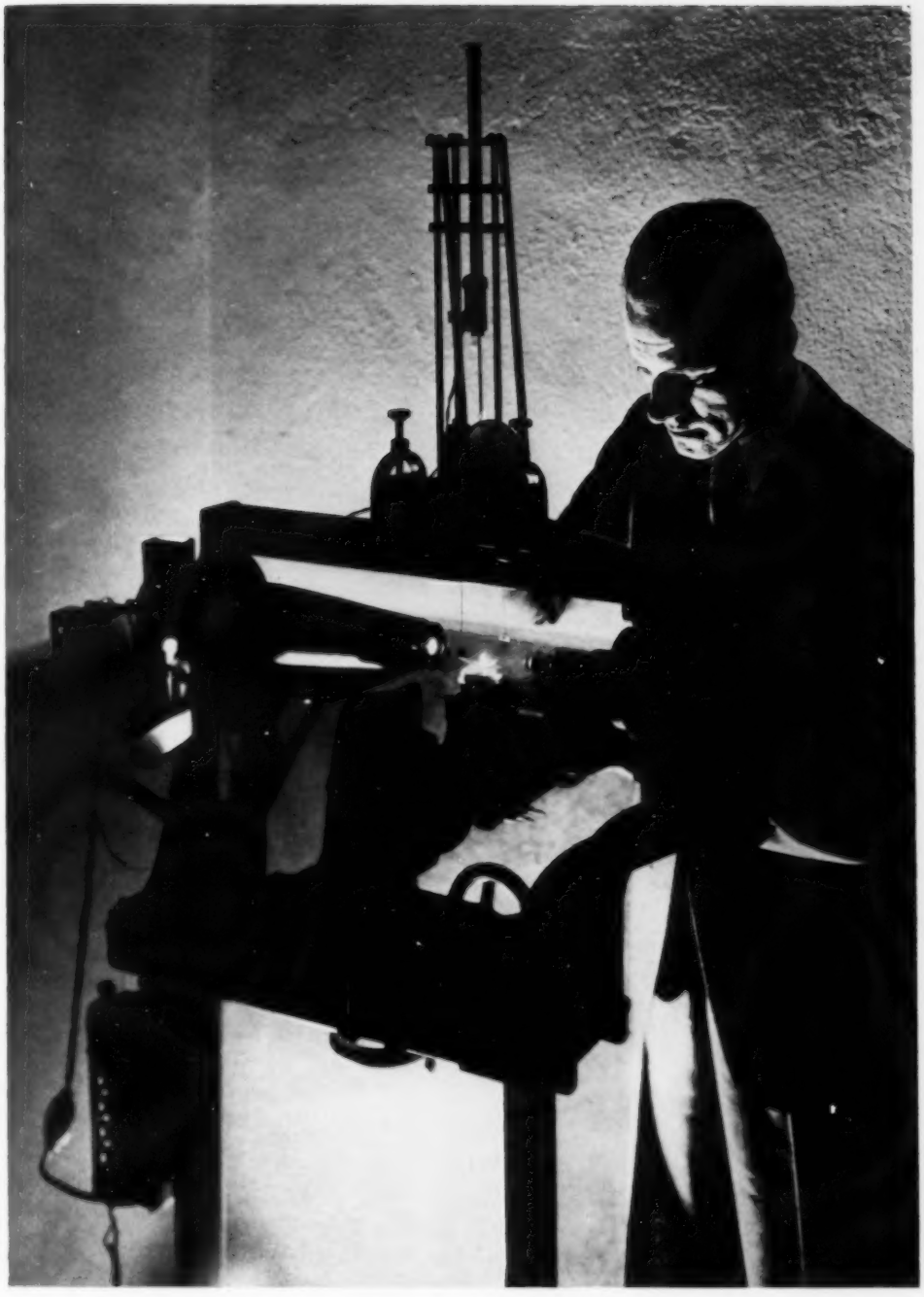
THOMAS W. WILLIAMS

MEASUREMENTS AND TESTS IN TELEPHONE RESEARCH

The activities of the Bell Telephone Laboratories include all the engineering arts which pertain to electrical communication and to the composition and construction of communication equipment, and all the sciences basic to those arts. Mathematics, physics, and chemistry are fundamental to its work; biology and botany enter into its consideration of textiles and timber products, and physiology and psychology into its knowledge of the action of vocal and auditory mechanisms.

In its search for the better thing and the better way, the Laboratories must understand old materials more thoroughly; must develop or invent new materials, alloys, compounds; must devise new methods, processes, techniques. Its fruitfulness depends on inventive ability backed by patient inquiry and checked by experiment. Painstaking tests often involve thousands of measurements with complex instruments built for the purpose. Some of these instruments, and the men who design, build, and use them, are shown in the pictures on the following pages.

The pitch and volume of sound emitted through an "artificial mouth" can be closely controlled. Hence, the transmitter being adjusted in front of one of these devices can be tested under absolutely standard conditions.



This projection microscope makes possible extremely accurate measurements of the thickness of the paper rings used to cushion the edges of telephone transmitter diaphragms.

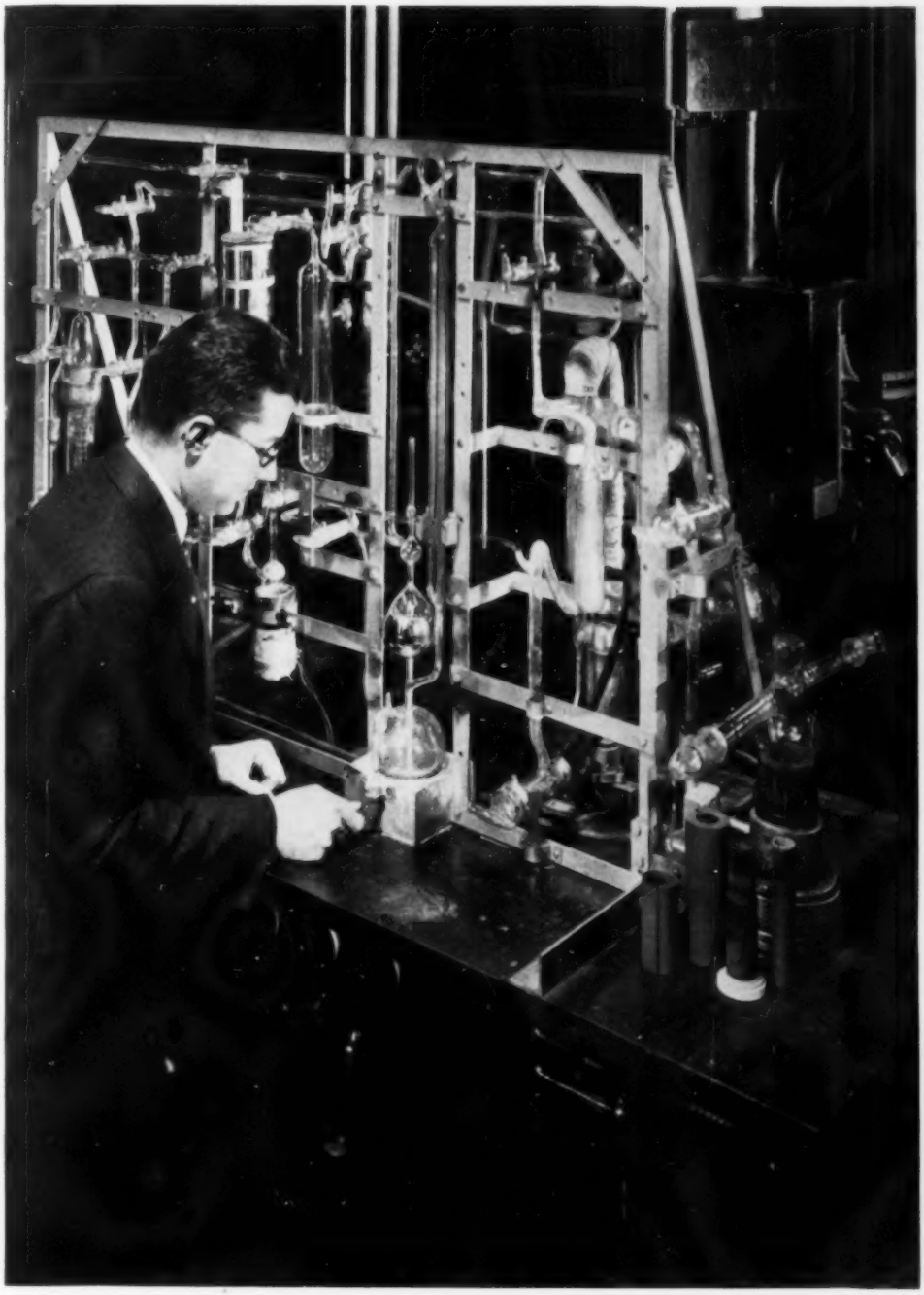
Delicate tests of sound perception are made from this elevated chair inside a curtained space. The curtains, by breaking up reflections from the walls, prevent the creation of a sound pattern.

A telephone transmitter, normally actuated by the voice, can also be actuated by an electric motor. This makes it possible, as in this picture, to establish definite conditions which are subject to accurate measurement.

The checkered pattern in the foreground registers the amount of motion in the diaphragm of a telephone receiver as it is pressed toward the pole pieces.

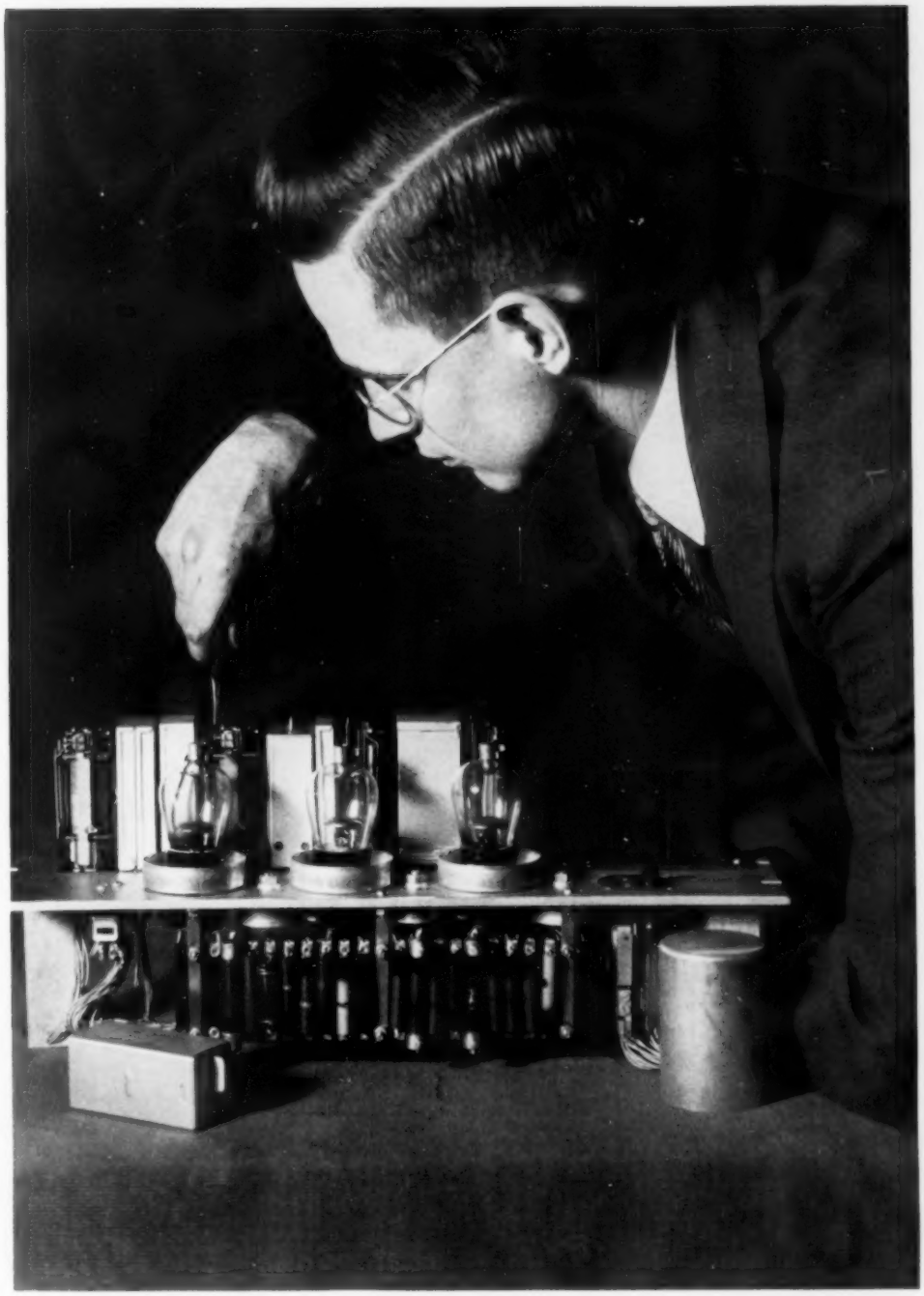
Measurement of the magnetic properties of a telephone receiver is made by means of the apparatus shown here.

A transmitter button is being placed inside this testing chamber—"the quietest place in New York City"—to measure the minute amount of noise which the carbon granules themselves originate.

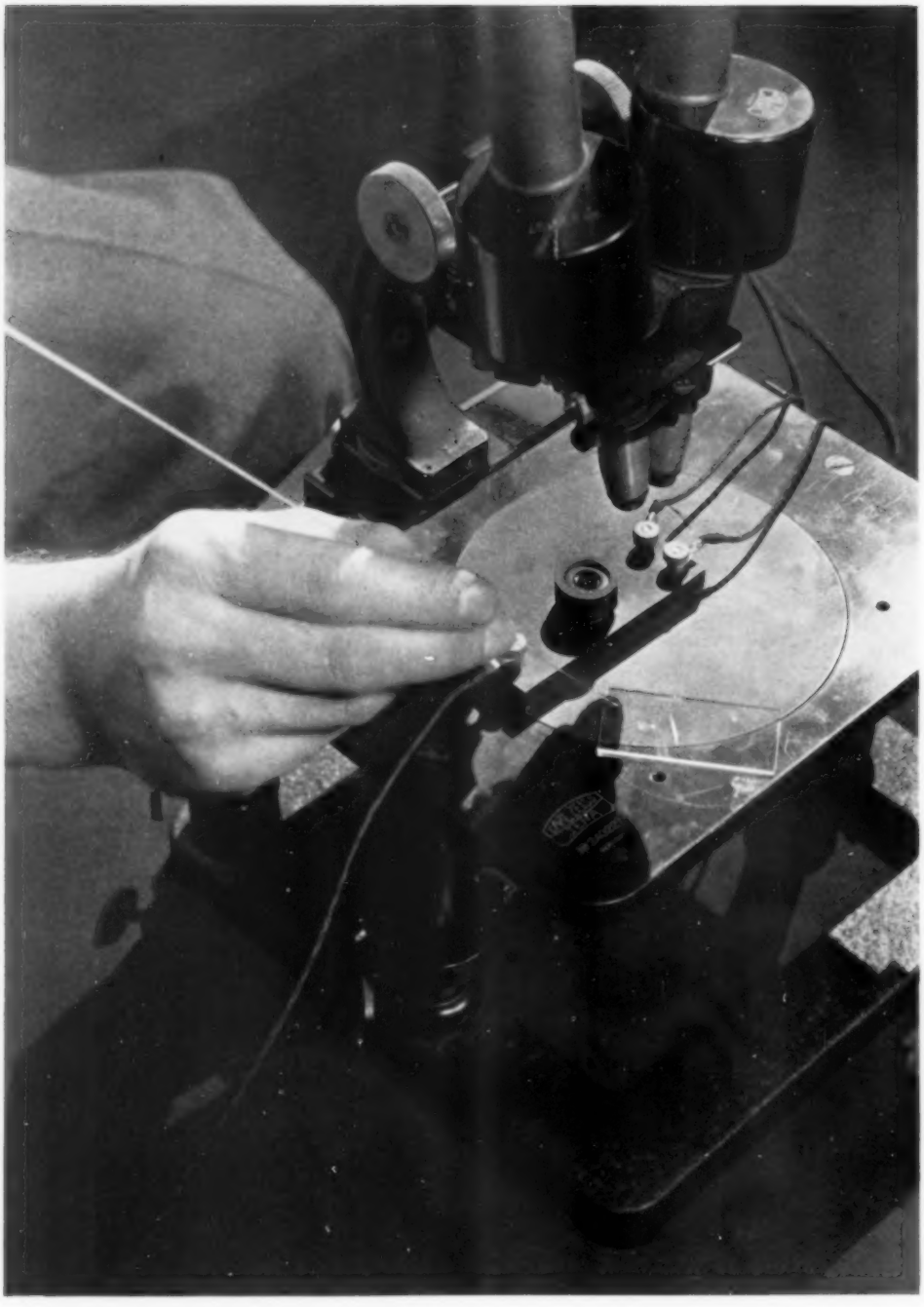


Metals, seemingly so solid, can absorb appreciable amounts of gas from the atmosphere. Since the various kinds of gases have different effects on the magnetic properties of metals, this apparatus has been devised to determine the kind and amount of gas present.

Precise measurements of the spacing of teeth on a motion-picture sprocket wheel reveal the cause of irregularities in sound picture reproduction.



Here is a device for measuring and counting—by strength, by kind, by number—the currents sometimes set up in telephone lines by lightning or by induction from power lines.

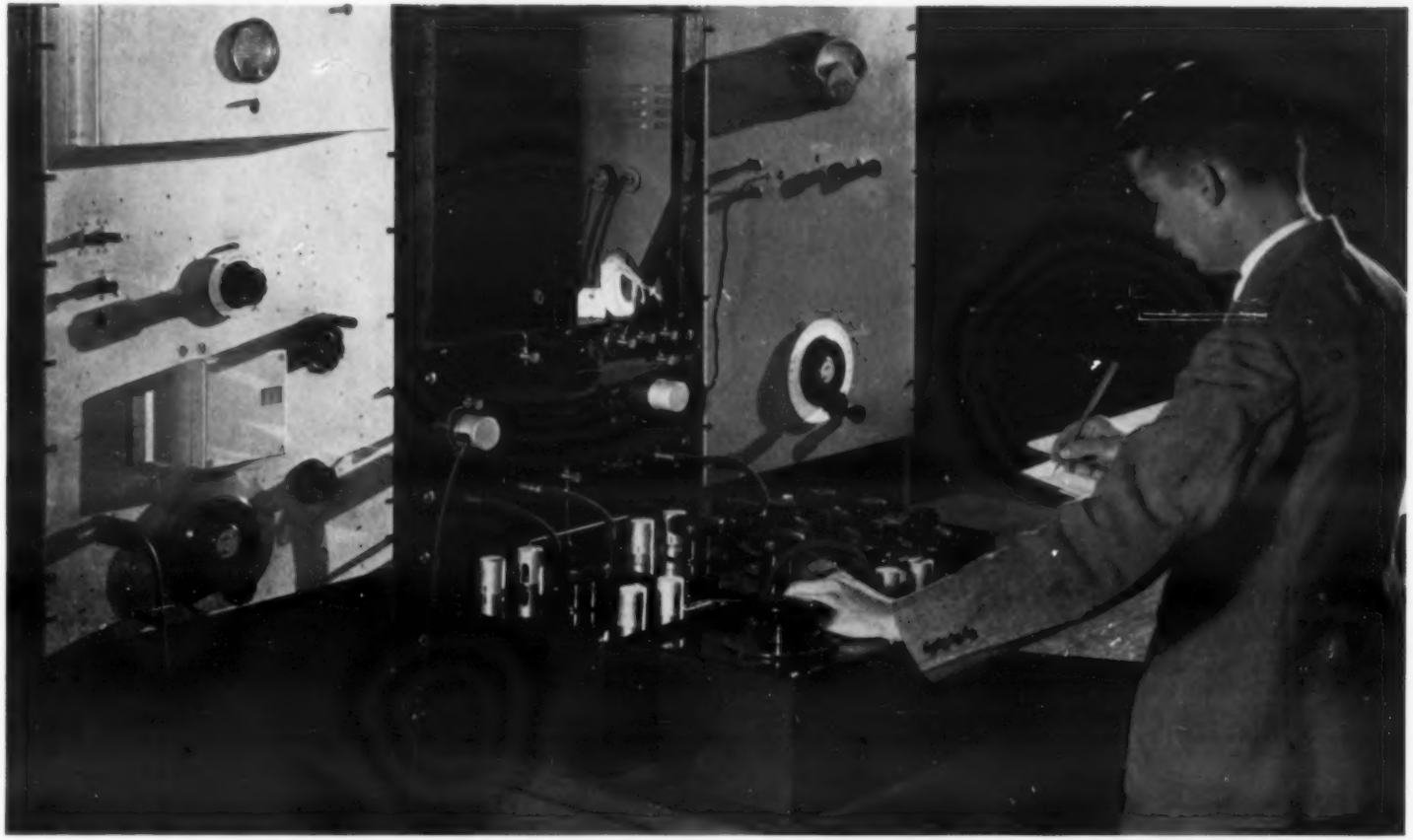


In analyzing minute samples, a bit of the drop of solution on the slide in the foreground is deposited on the cell in the center of the table, where its electrolysis is observed through the binocular microscope. Copper, for example, gives a characteristic color to the electrode.

Time is an important element in testing the effectiveness of the various preservatives with which telephone poles may be impregnated. Here hundreds of bits of wood, variously treated, are exposed to attack by fungi under controlled conditions.

Motion pictures taken at the rate of 4,000 exposures a second, and then projected slowly or studied as separate pictures, reveal much about the performance of moving parts. Here the armature of a relay is about to be photographed in motion.

The transmission characteristics of telephone lines vary with changes in temperature. Here, measurements are being made of the constants of a reel of cable in the cold chamber just visible at the right of the picture.



The high quality of radio broadcast network programs rests on painstaking studies in the Laboratories. This instrument measures the characteristics of various devices used for program transmission.

Notes on Recent Occurrences

OPEN DIRECT SERVICE TO AUSTRALIA

DIRECT telephone contact between the United States and Australia was established on December 20 over a short-wave radiotelephone circuit between San Francisco and Sydney. The occasion was marked by an exchange of greetings between government and telephone officials over a circuit linking Washington with Sydney and Melbourne.

Telephone service between this country and Australia has hitherto been set up over two radio circuits interconnected at London. The new route shortens the distance by more than 4,000 miles and provides a much better quality of circuit.

The San Francisco-Sydney circuit is operated by the American Telephone and Telegraph Company and Amalgamated Wireless (Australasia) Ltd. The circuit interconnects all Bell and Bell-connecting telephones in the United States, Cuba and Mexico with the Australian Post Office system. On account of the shorter distance over the direct route, the rate is materially less than heretofore. A three-minute conversation between San Francisco and Sydney, for instance, costs $21 on weekdays and $15 on Sundays. The rates are somewhat higher for points on the Atlantic seaboard.